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HIGH ENERGY PHYSICS DIVISION
SEMIANNUAL REPORT OF RESEARCH ACTIVITIES

January 1, 1998 - June 30, 1998

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I. EXPERIMENTAL RESEARCH PROGRAM

I.A EXPERIMENTS WITH DATA

I.A.1 Medium Energy Physics Polarization Program

During the reporting period of January 1998 through June 1998, work continued on Brookhaven AGS experiments E897 ($\eta \to \pi^0 \gamma\gamma$); E913 ($\pi^- p \to N^*,\ \Delta^* \to neutrals$); and E914 ($K^- p \to \Lambda^*,\ \Sigma^* \to neutrals$) using the Crystal Ball detector. In preparation for the upcoming runs in July and September - October, Argonne personnel worked on calibrations and testing of all the Crystal Ball counters using a ^{137}Cs radioactive source. Some bad photomultipliers and bases were replaced. They also worked on Argonne neutron counters, some of which were in use for the 1997 runs. Repairs to about a dozen photo-multiplier bases were made. Additional counters were installed, and electronics modified. Many new delay boxes were constructed to allow each of the 50 photomultipliers to be read out in ADCs and TDCs. The voltages of the phototubes were adjusted using cosmic ray muons passing through the counters. These detectors will be important for many of the reactions to be studied, especially the $\pi^- p \to n\gamma$ radiative capture channel, in order to suppress backgrounds from $\pi^- p \to n\pi^0$. An Argonne physicist also worked with an Abilene Christian University physicist and students to repair some of the electronics for the Crystal Ball, and with an Arizona State University graduate student to document the electronic logic.

A George Washington University graduate student, Aziz Shafi, was partially supported by ANL funds and was guided by Argonne physicists during this period. The reaction he is studying, $\pi^- p \to \gamma\, n$, will detect the γ in the Crystal Ball, and the neutron either in the ANL neutron counters or in the Crystal Ball. Constraints from the correlation of the laboratory scattering angles and from coplanarity were shown to effectively eliminate most background from the much larger cross section for $\pi^- p \to \pi^0 n$.

The analysis of $K^- p$ reactions from a few runs in 1997 continued with collaborators from Valparaiso University. A small number of events were found corresponding to, $K^- p \to \Lambda^0 \pi^0$, and $K_S^0 n$. Backgrounds from pion reactions and from empty target runs were studied. The source of some unusual topology events, termed worms or snakes, was identified with kaon decays upstream of the target that pass through gaps in the veto counter system; see Figure 1. A Crystal Ball note was written to describe these calculations. The new kaon data expected in July should allow a better sample of events to further develop analysis techniques.

Work also continued on papers describing the results of *pp* elastic scattering spin experiments from Saclay. The spin observables $P = A_N = A_{oono} = A_{ooon}$ and $C_{NN} = A_{NN} = A_{oonn}$ were measured for $\theta_{c.m.} \sim 60 - 90^\circ$ at over 30 beam kinetic energies between 1800 and 2800 MeV. Two papers are nearly complete, and should be sent out to collaborators within the next several months. In addition, several new papers were published or submitted ("Angular Dependence of *pp* Spin Correlation and Rescattering Observables Between 1.80 and 2.10 GeV," Eur. Phys. J. **C1**, 131 (1998); "Direct Reconstruction of *np* Elastic Scattering Amplitudes," Nuo. Cim. **111A**, 13 (1998); "The *pp* Elastic Scattering Analyzing Power Measured with the Polarized Beam and the Unpolarized Target Between 1.98 and 2.80 GeV," submitted to Nucl. Phys. A).

(H. M. Spinka)

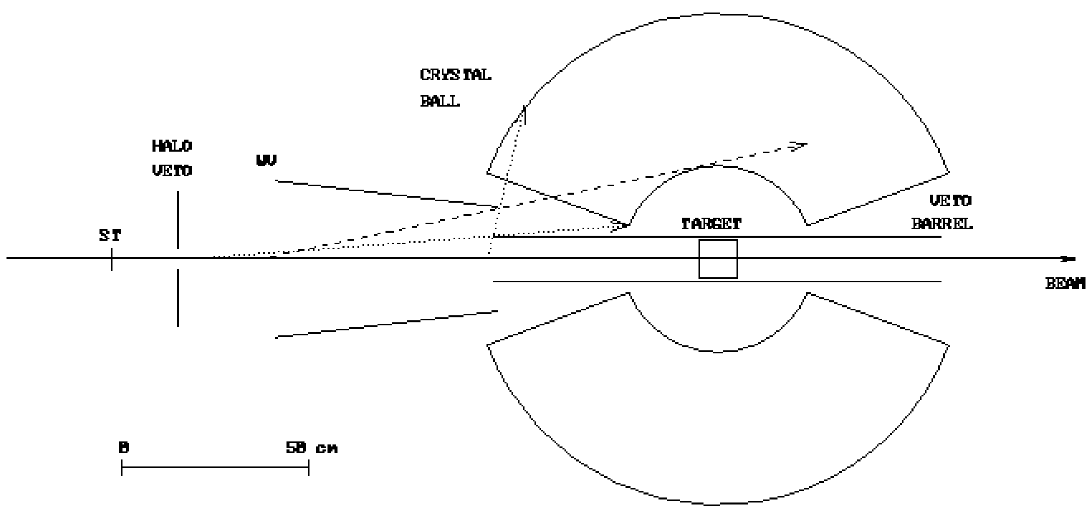


Figure 1. Side view of the Crystal Ball experimental apparatus, including the active volume of the Crystal Ball, and various scintillation counter veto's. Three trajectories of charged particles from kaon decays that miss these veto's are shown.

I.A.2 Collider Detector at Fermilab

a. CDF PHYSICS

Bob Blair and Steve Kuhlmann are working with several students on QCD related photon analyses. A student has been recruited to work on the inclusive photon analysis for the 94-95 data. Bob, working with students at the University of Chicago, helped to conclude the photon pair exotics searches, submitting limits in a letter and an article. Steve helped get out a paper on jet longitudinal distributions in photon events. Steve continues to lead a group studying dijet mass issues, now looking at defining combinations of detector information optimized to improve dijet mass resolution for searching for Higgs decay to b pairs with the luminosity upgrade.

Adam Hardman is making progress in his effort to use the transverse mass tail in the muon W sample to determine the W width. Bob Wagner continues as co-convener of electroweak physics and continues working with the group studying radiative W and Z events. Tom LeCompte and Larry Nodulman served as internal reviewers helping to produce a readable article documenting the dimuon Z and Drell-Yan study.

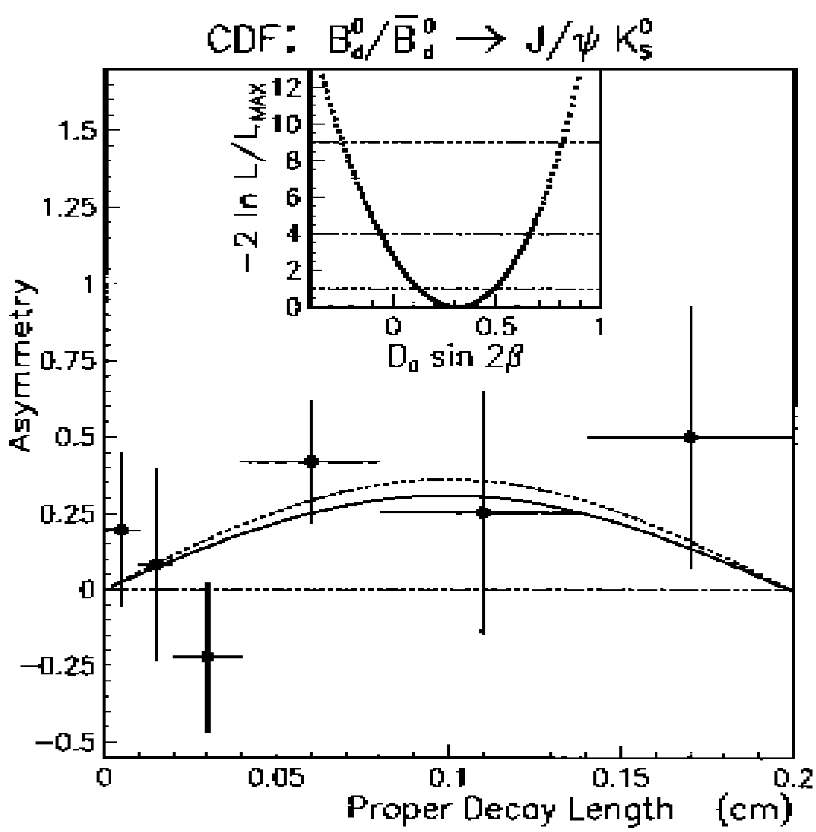


Figure 1. CP asymmetry as a function of proper time. The curves are fits.

In b physics, Barry Wicklund, with Fumi Ukegawa, got out a paper on improved charged and neutral B meson lifetime measurements, using semileptonic decays. Karen Byrum has become a consulting expert on issues of electron trigger efficiency. Barry and Larry Nodulman served as internal reviewers for a CP study by the MIT group using same side tagging of (anti) B^0 -> ψ K^0_S. The results were submitted as a letter, with an accompanying article on same side tagging technique and mixing studies. The CP violating asymmetry is shown in Fig. 1. The result, sin $2\beta = 1.8 \pm 1.1$, demonstrates the method which can be used effectively with higher statistics.

Barry, as co-convener for b physics, helped many analyses along, notably the discovery of the B_C. This “last meson” is observed in the decay B_C -> ψ $l\nu$ for dimuon ψ decays as a mass enhancement, shown in Fig. 2. The missing neutrino makes the peak broad so that background understanding is important and the mass determination is not so precise, $m(B_C)=6.40 \pm 0.41$ GeV/c^2. The lifetime measurement is shown in Fig. 3; the lifetime is similar to charm particles, 0.46 ±0.19 ps.

(L. Nodulman)

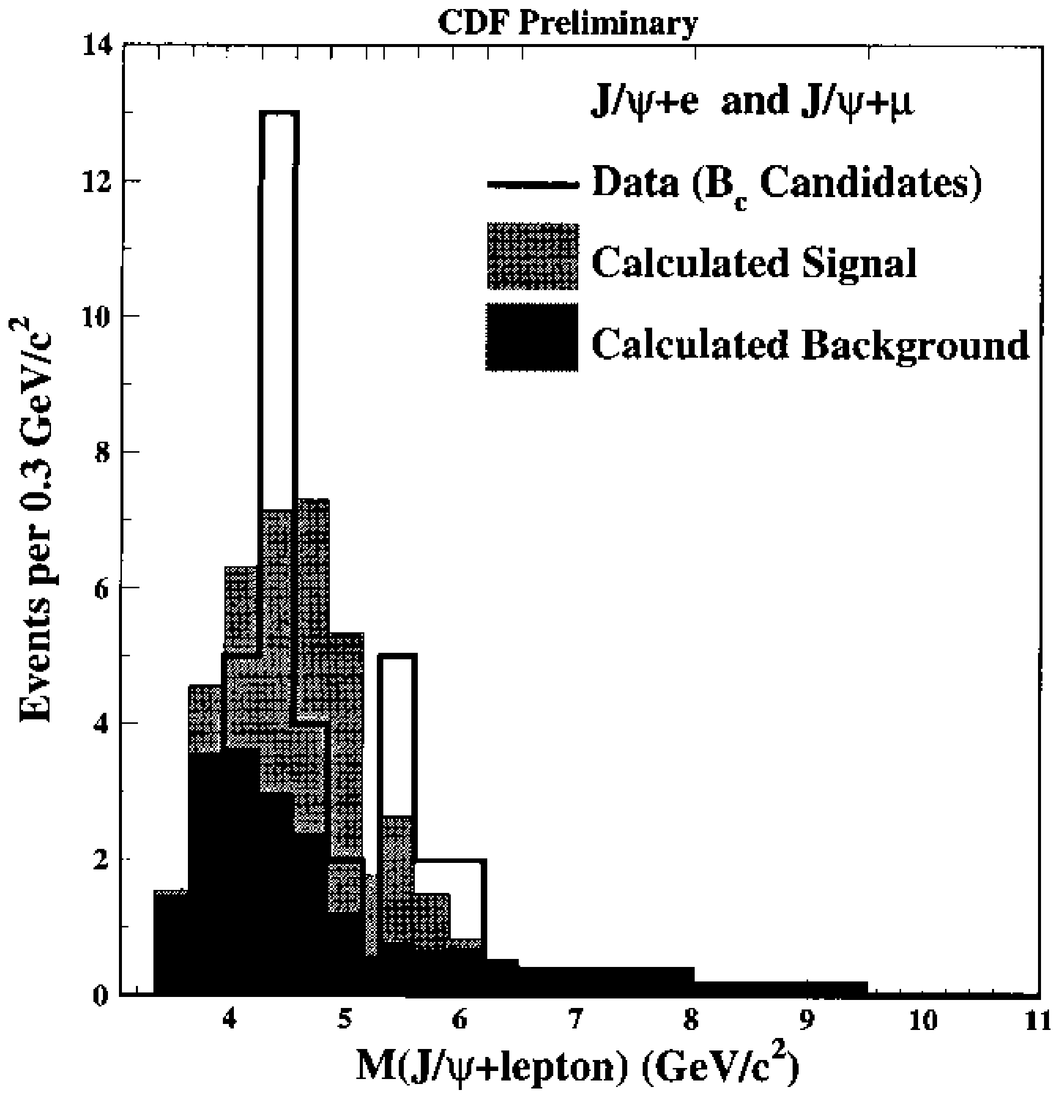


Figure 2. Lepton Psi mass spectrum. A small bin corresponding to $B^0 \rightarrow \psi K$, where the K fakes a lepton, has been removed. The result is no longer preliminary.

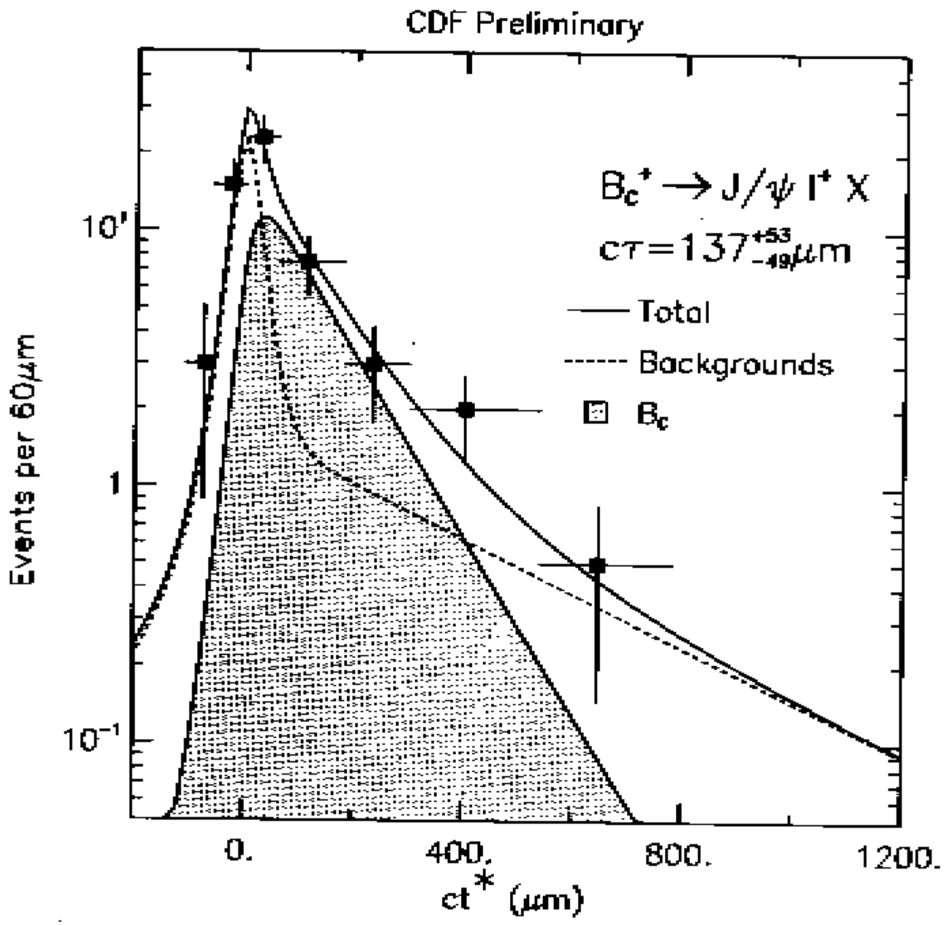


Figure 3. Proper time distribution fit to prompt and *b* background, and signal. The result is no longer preliminary.

b. CDF Tevatron Run 2 Preparation

Tom LeCompte continues as co-project manager for CDF muon upgrades, working with various groups on new absorber, chambers, and scintillators for the extended muon coverage.

Bob Wagner and Randy Keup are working on putting calorimeter software into the new Run 2 framework which is C++ based but allows FORTRAN code to be used. Randy has also taken charge of slow control for muon and wire chamber high voltage. Jimmy Proudfoot helped to develop a scheme for a calibration database for reconstruction.

As physics conveners, Bob Wagner and Barry Wicklund have been helping to develop a strategy for triggers and datasets, developing paths for events to get through the various levels of online triggers through reconstruction into accessible form.

Hardware work is discussed under detector development.

(L. Nodulman)

I.A.3 Non-Accelerator Results at Soudan

a. Physics Results

Along with other underground experiments, Soudan 2 is measuring the flavor content of contained atmospheric neutrino events and finding evidence for neutrino oscillations. It is also possible to measure the flux of atmospheric neutrino induced muons from the rock around Soudan 2. There is a large background from downward atmospheric muons at low zenith angle. The inability of Soudan 2 to reliably distinguish muon direction narrows the search to those muons near 90^{o}. This still leaves 18 percent of all solid angle, when we cut at a slant depth corresponding to 14000 mwe, above which there is no atmospheric muon background. In addition to a measurement of the atmospheric ν flux, Soudan 2 can search for very high energy ν's from Active Galactic Nuclei. Several authors have suggested that large black holes accreting mass over cosmological timescales are the source of the very highest energy cosmic rays. These ν's would be distinguished from atmospheric ν's by having large stochastic energy loss along the muon tracks which traverse the detector, as a result of the increase in such energy loss for high energy (TeV) muons. The expected atmospheric and neutrino induced muon fluxes versus slant depth, and the corresponding zenith angles at Soudan, are shown in Figure 1.

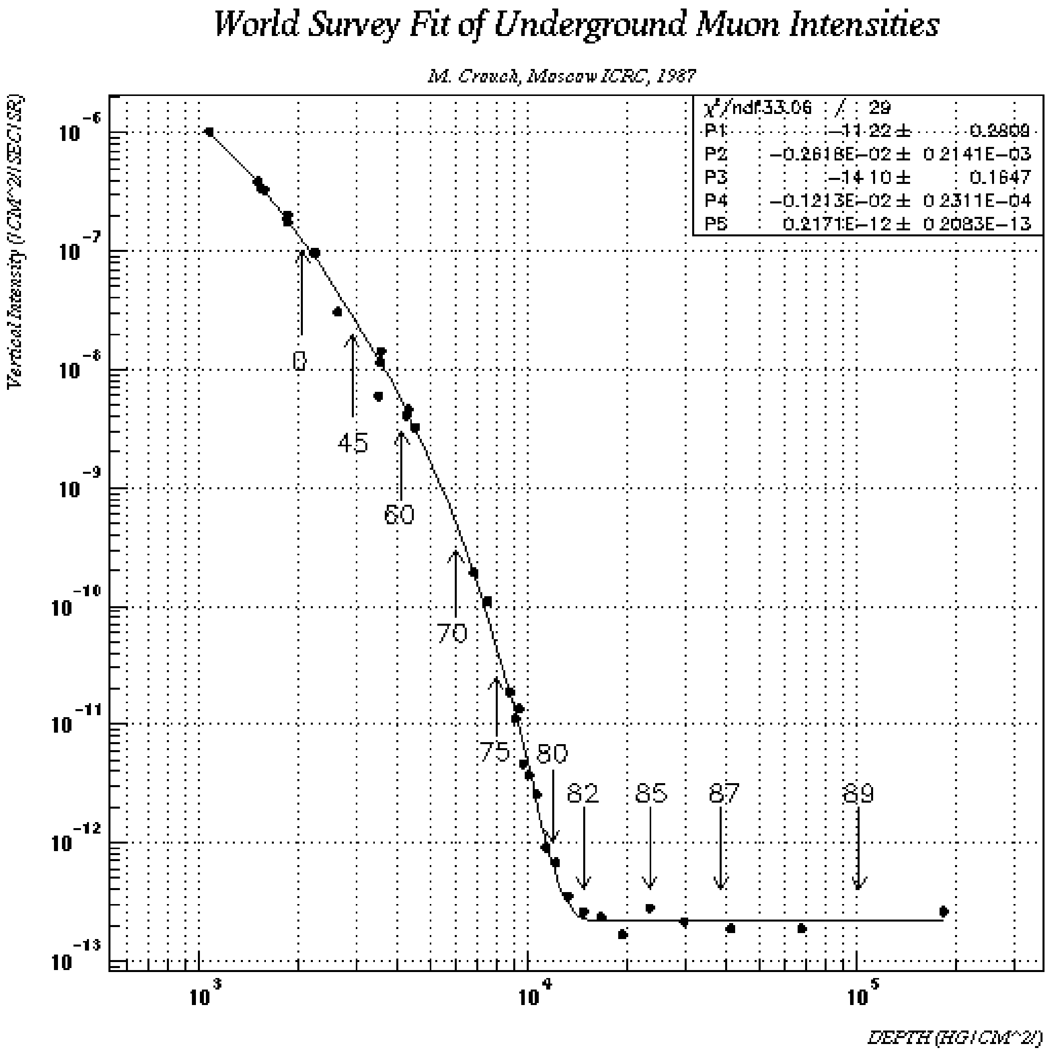


Figure 1. A compilation from Crouch of the vertical muon intensity versus slant depth. Zenith angles averaged over azimuth at Soudan 2 are shown.

The Soudan muon reconstruction software finds muons at all angles with high efficiency. However, a small fraction of mis-reconstructed events become a background for all zenith angle. Since there is a small number of events with high zenith angle, the background after reconstruction from mis-reconstructed events is large. However, these events are simple to identify during scanning, and are easily rejected. During a livetime which corresponds to $1.23x10^8 s$, 703 muons with a zenith angle in excess of 78° were identified after a tracklength cut of 1.75 m. The event with the highest zenith angle is shown in Figure 2.

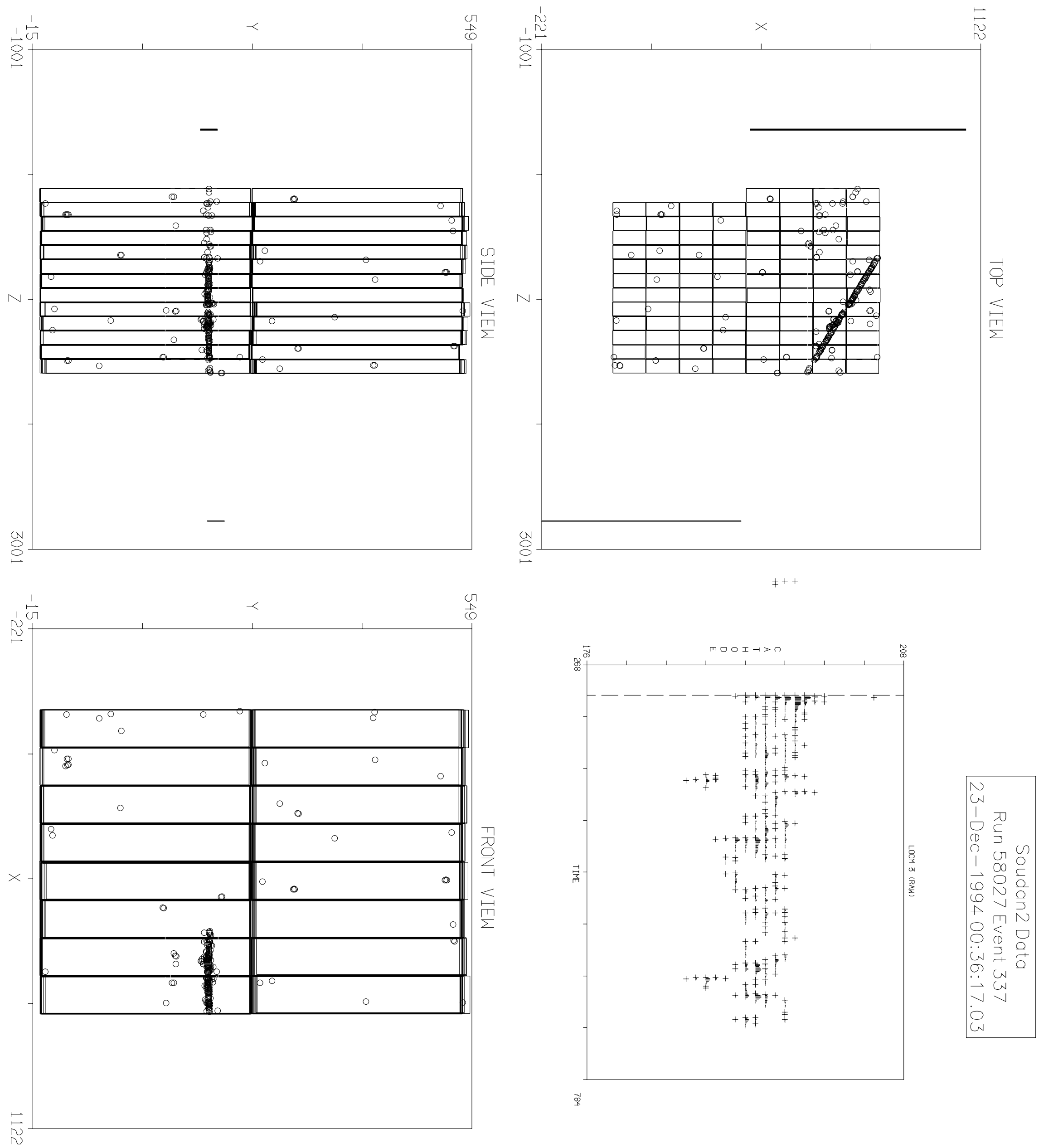


Figure 2. A high zenith angle event in Soudan 2.

As a result of variations in the terrain above Soudan 2, the conversion of a muon direction into an overburden must take into account the topography and geology of the area. A digitized map of the elevations as a function of latitude and longitude has been obtained from the Minnesota Geological Survey. A study of the geology of the area has been conducted using single muons as a function of zenith angle and comparing them to the depth-intensity curves as a function of azimuth. It has been found that the average density of the rock for muons near 60° is 2.74 *gm/cm*^{3}, compared to 2.86 for vertical muons and 2.63 for standard rock. Using this value, we have calculated the contour in zenith and azimuth corresponding to 14k mwe slant depth and this is shown in Figure 3, along with the 703 horizontal muons. We find that 44 neutrino candidates with a background estimated at 0.2 events.

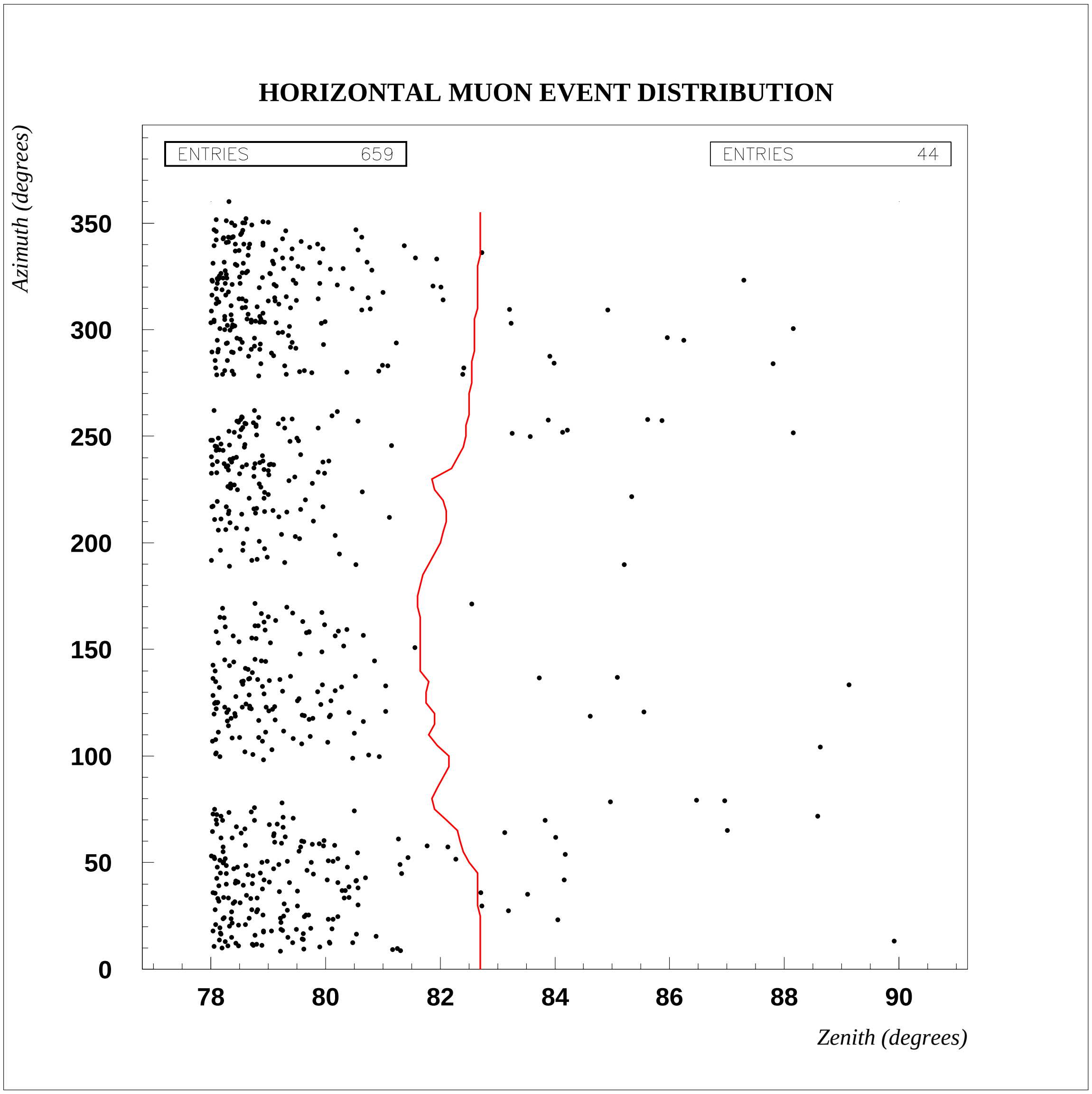


Figure 3. The horizontal muon events are shown with azimuth and zenith. The line shows the calculation of 14 kmwe. 44 events are neutrino induced muon candidates.

The calculation of a neutrino flux requires an estimate of the solid angle, the effective area, the detection efficiencies, and the exposure. The solid angle is calculated from Figure 3 and is found to be 1.77 sr. This includes a factor of two to account for acceptance beyond 90°. The area depends on zenith and azimuth and is determined by Monte Carlo methods as shown in Figure 4. For events with a zenith greater than 82°, the effective area is 82.4 m^2. The trigger and scan efficiencies were calculated from Monte Carlo and double scans, respectively. The program efficiencies were estimated and the systematic error was increased to account for this uncertainty. With the exposure of 1.23 $10^8 s$, and ε = .69, we calculate the neutrino induced muon flux to be $3.46 \pm 0.52 \pm 0.61 \times 10^{-13}\ cm^{-2}\ sr^{-1}\ s^{-1}$.

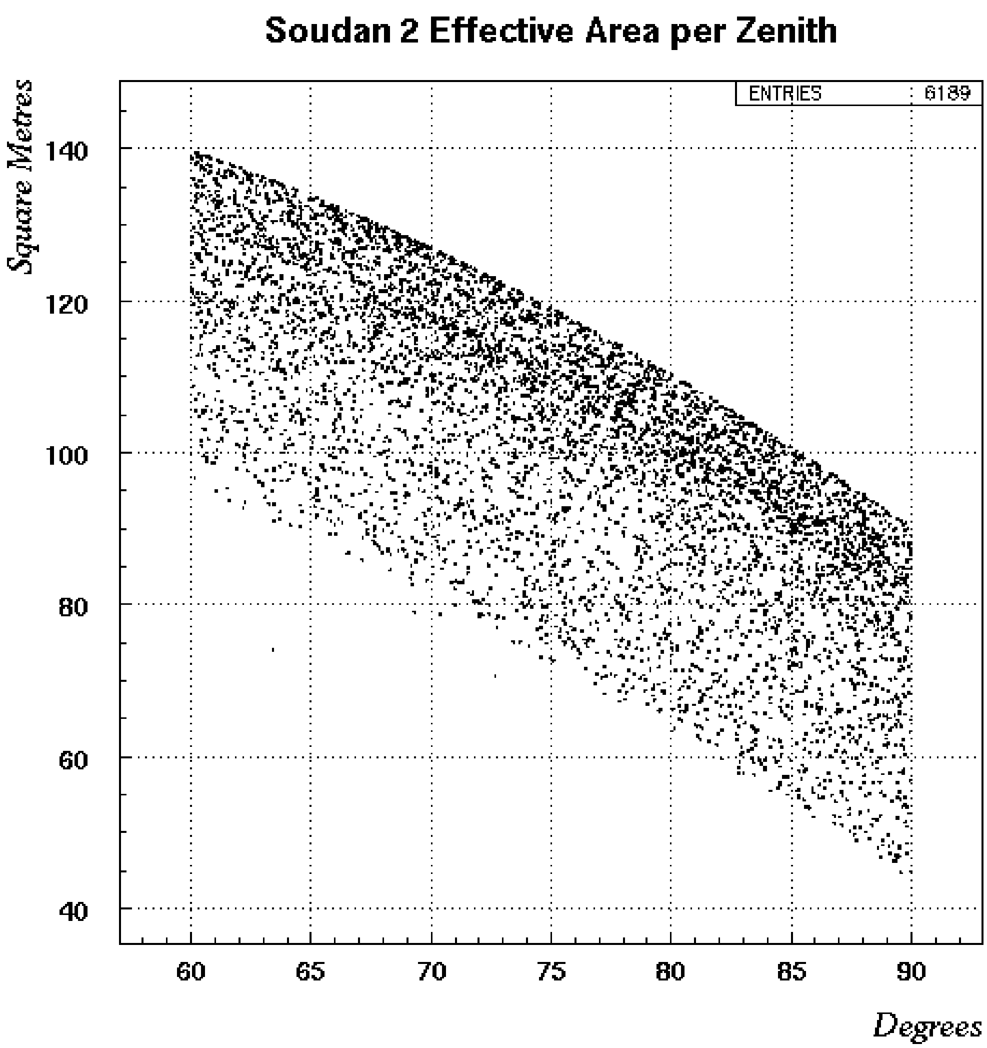


Figure 4. The plot shows a Monte Carlo calculation of the effective area of the detector. The two bands which are evident are due to two slightly different detector geometries when half-wall maintenance was under way.

To search for particular AGN's, we have projected the muons into the sky as shown in Figure 5. To study the effect of energy loss of high energy muons in Soudan 2, we have used a GEANT based simulation of very high energy muons traversing the Soudan detector, and studied the non-ionization energy loss. We find that 60%, 91% and 99% of such muons underwent a loss of 20 GeV or more from 5, 20 and 100 TeV muons. None of the 44 muons have a large stochastic energy loss. Thus we are able to set a limit on the flux of high energy neutrino induced muons as shown in Figure 6.

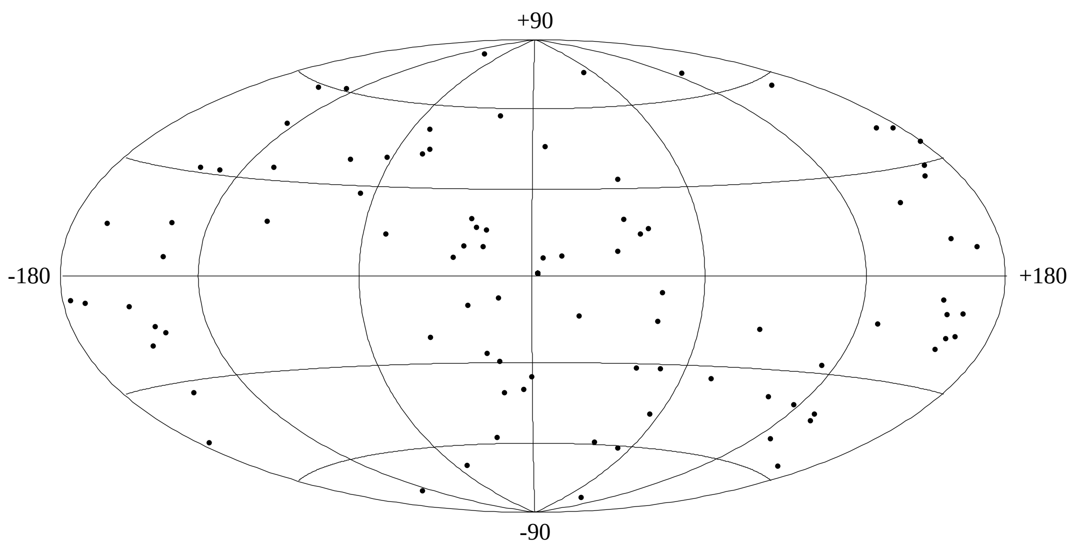


Figure 5. The 44 events from the HMU sample have been projected upon the celestial sphere in galactic coordinates.

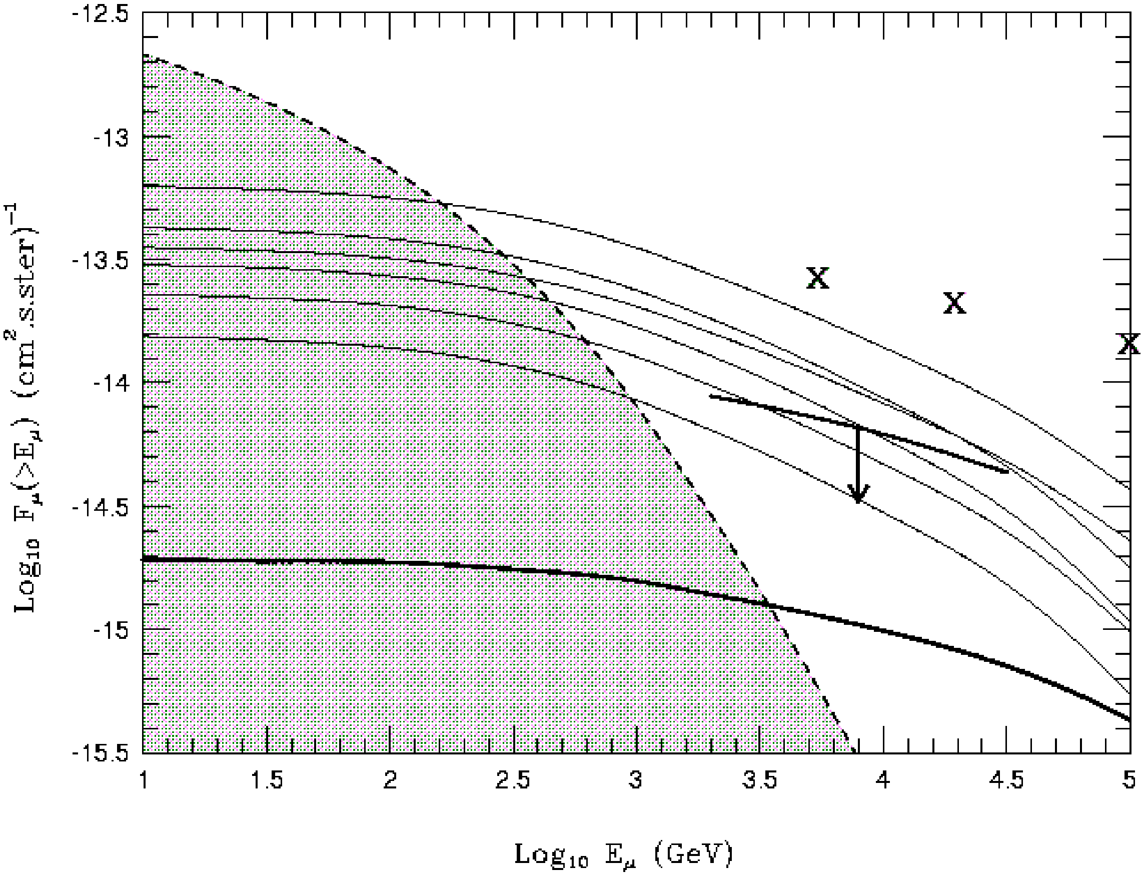


Figure 6. Horizontal muon flux limits (X) are compared to the calculation of the atmospheric neutrino flux (shaded), various AGN model calculations and the suspect Frejus limit.

b. Experimental Apparatus, Operation and Maintenance

Argonne physicists continued to make substantial contributions to the maintenance and operation of the detector. Major activities included ongoing improvements of detector and electronics performance. Argonne physicists also continued the development of software to make use of dE/dx information from the detector.

c. Planning Activities

The Soudan group plans to run the detector for nucleon decay, atmospheric neutrino and other cosmic ray studies until an exposure of 5.0 kt-year fiducial volume is achieved. After that, the Soudan detector will become an integral part of the MINOS long-baseline neutrino oscillation experiment. The progress on that project is described elsewhere in this report.

(M. C. Goodman)

I.A.4 ZEUS Detector at HERA

a. Physics Results

Five papers were published in this period and five more manuscripts were submitted for publication.

i) *Dijet Cross Sections in Photoproduction at HERA*

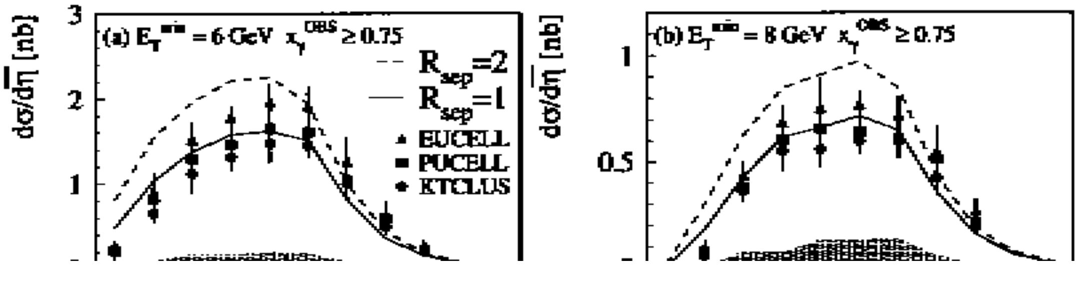
Photoproduced dijet cross sections have been measured in the hadronic final state for different kinematic regions. The measured cross sections vary up to a factor of two when different cone or clustering algorithms are used for the definition of jets. This behavior is similar to that predicted by theoretical calculations by varying the R_{sep} parameter in order to reproduce different jet algorithms. The R_{sep} parameter is introduced in the calculation of jet cross sections to reproduce the effect of starting the experimental jet search using seed cells and the handling of jets with overlapping regions. Figure 1 shows the differential cross section at the hadron level versus the averaged pseudorapidity $\overline{\eta}$ of the jets. The upper plots correspond to a sample enriched in direct photoproduction events, selected with $x_\gamma^{OBS} > 0.75$. The variable x_γ^{OBS} is defined as

$$x_\gamma^{OBS} = \frac{E_T^{jet1} e^{-\eta^{jet1}} + E_T^{jet1} e^{-\eta^{jet1}}}{2yE_e}$$

where $E_T^{jeti} (\eta^{jeti})$ are the transverse momentum (pseudorapidity) of jet i. The data in the lower plots were selected with $x_\gamma^{OBS} < 0.75$ and are dominated by resolved photoproduction events, where a parton emitted from the photon interacts with the parton emitted from the proton.

Comparison of the direct photon cross sections $(x_\gamma^{OBS} > 0.75)$ with next-to-leading order QCD calculations shows good agreement in both shape and magnitude over a wide range of E_T^{jet} and η^{jet} and for the three-jet definitions. Calculations for the resolved photon cross sections in the region $0.3 < x_\gamma^{OBS} < 0.75$, which include jets with $6\,\text{GeV} < E_T^{jet} < 11\,\text{GeV}$, are found to lie below the data. However, for higher jet energies the calculations are consistent with the data. Further investigations are under way to clarify the reasons for the disagreement at low E_T^{jet}. In particular, several studies explore the effects of possible multi-parton interactions.

ZEUS 1994



dσ/dη̄ [nb]
(a) E_T^{min} = 6 GeV $x_\gamma^{OBS} \geq 0.75$
R_{sep}=2
R_{sep}=1
EUCELL
PUCELL
KTCLUS
(b) E_T^{min} = 8 GeV $x_\gamma^{OBS} \geq 0.75$

three different jet algorithms and are compared to NLO QCD calculations using $R_{sep} = 1$ (solid curves) and $R_{sep} = 2$ (dashed curves), see text for details. The error bars represent the combined systematic and statistical uncertainty, excluding the principal correlated uncertainties, which are shown in the shaded band (see text). The band indicates the maximum uncertainty for the three jet finders. The individual uncertainty for each jet finder is given in the table.

ii) *Charged Particles and Neutral Kaons in Photoproduced Jets at HERA*

The properties of charged particles $(h^{\pm})$ and K^{o} mesons in photoproduced events have been studied. In each event at least one reconstructed jet was required in the calorimeter with measured $E_T > 7\,\text{GeV}$, centrally produced in the laboratory frame. Correction factors were applied to evaluate the numbers of $h^{\pm}$ and K^{o} per jet at the final state hadron level, with $E_T(\text{jet}) > 8\,\text{GeV}$ and $|\eta(\text{jet})| < 0.5$ for events in the γp center-of-mass energy range 134 < W < 277 GeV. The distribution of $h^{\pm}$ is found to be fairly well described by the standard version of PYTHIA, whereas that of K^{o} mesons is not. Outside the jets, more $h^{\pm}$ and K^{*} are found than predicted; the latter can be to some extent remedied by using a version of PYTHIA which includes a simulation of multiparton interactions in resolved events. Taken overall, the number of K^{o} within jets corresponds to a reduced value of the strangeness suppression parameter $P_s P_u$ in PYTHIA.

Fragmentation functions have been extracted for $h^{\pm}$ and K^{o} in direct photoproduced jets and are compared with corresponding data from $e^{+}e^{-}$ annihilation and from deep inelastic scattering, see Figures 2. Agreement is good for z > 0.1 (0.15) for $h^{\pm}(K^{o})$, where z is defined as

$$z = E_{hadron} / E_{jet}.$$

This, together with the agreement found in this region with PYTHIA, represents a confirmation of the idea of a universally valid description of parton fragmentation.

iii) *Measurement of the t Distribution in Diffractive Photoproduction at HERA*

Photon diffractive dissociation, $\gamma p \rightarrow Xp$, has been studied using ep interactions where the virtuality Q^2 of the exchanged photon is smaller than 0.02 GeV^2. The squared four-momentum t exchanged at the proton vertex was determined in the range $0.073 < |t| < 0.04\,\text{GeV}^2$ by measuring the scattered proton in the ZEUS Leading Proton Spectrometer. In the photon-proton center-of-mass energy interval 176 < W < 225 GeV and for masses of the dissociated photon system $4 < M_X < 32\,\text{GeV}$, the t distribution has an exponential shape, dN/d|t| $\propto$ exp(-b|t|) with a slope parameter

$b = 6.8 \pm 0.9(\text{stat})^{+1.2}_{-1.1}(\text{syst.})\,\text{GeV}^2$, see Figure 3.

In a comparison of the present measurement and deep inelastic data at an average $Q^2 = 8\,\text{GeV}^2$, a weak Q^2 dependence of the t -slope in diffractive photon dissociation is observed. This dependence has been predicted by several QCD-based models of diffraction.

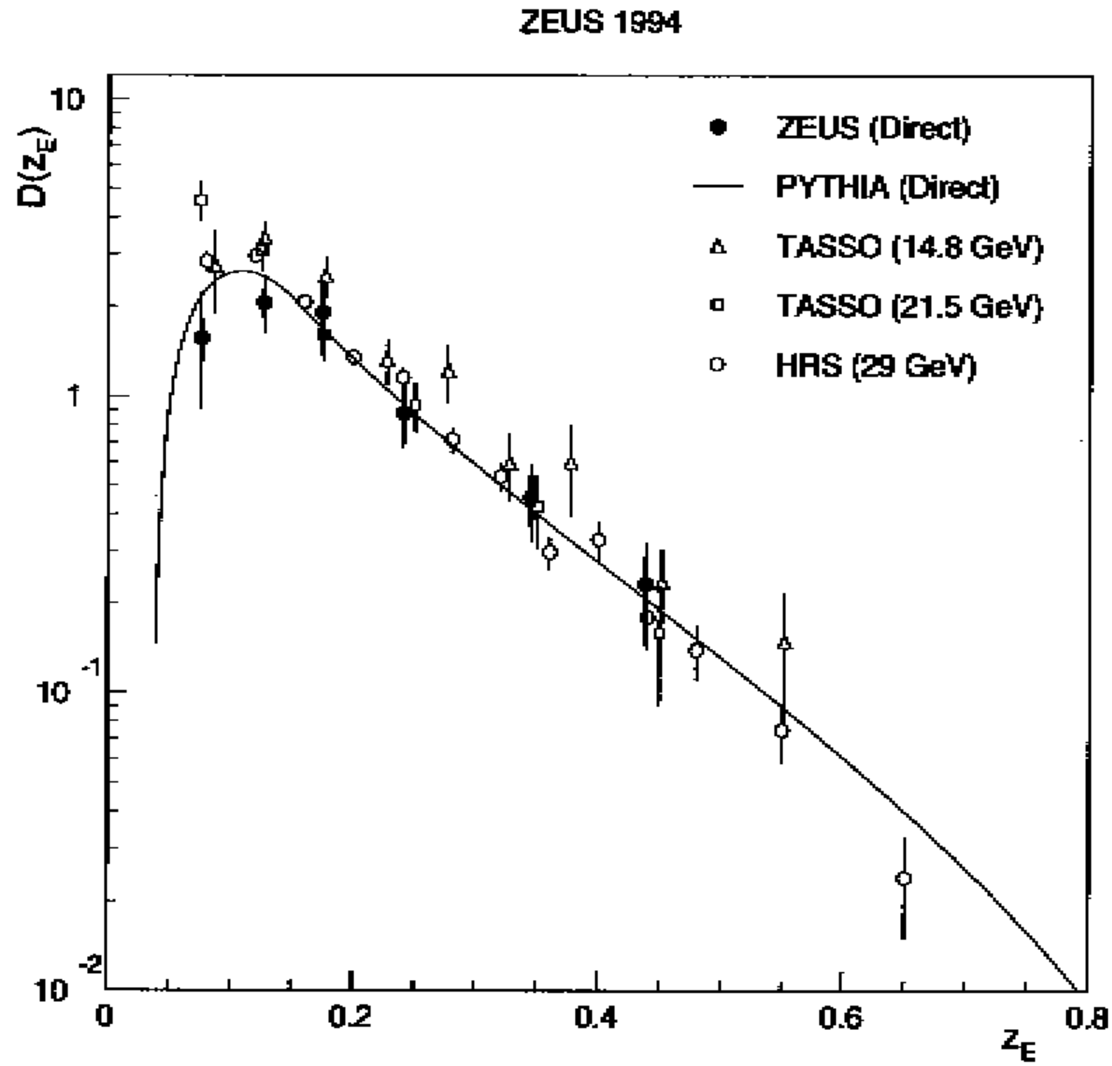


Figure 2. Fragmentation functions $D(z_E)$ for K^0, obtained from direct-enhanced events and corrected to "pure direct" values; z_E definitions correspond to those for $h^{\pm}$. Also plotted are standard PYTHIA predictions for the LO direct process and data from previous experiments at similar jet energies, with center of mass energies as indicated [39.40]. Errors on the TASSO and HRS points are total errors.

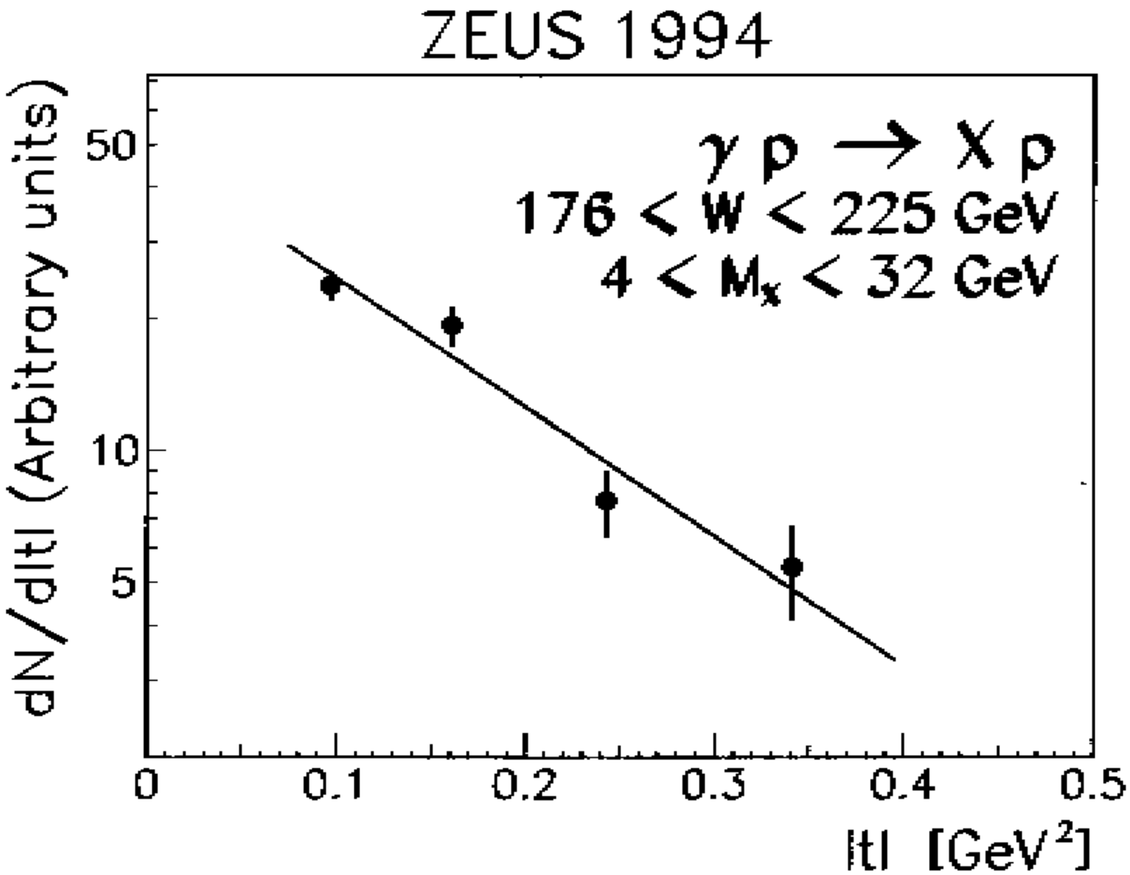


Figure 3. Differential distribution dN/d|t| for photon diffractive dissociation, $\gamma p \rightarrow Xp$, in the kinematic region 176 < W < 225 GeV and 4 < M_x < 32 GeV. The vertical bars indicate the size of the statistical uncertainties. The line is the result of the fit described in the text. The scale on the vertical axis is arbitrary.

iv) *Elastic and Proton-dissociative* ρ^o *Photoproduction at HERA*

This paper presented a high statistics study of ρ^o photoproduction for 50 < W < 100 GeV and |t| < 0.5 GeV^2, where t is the 4-momentum transfer at the proton vertex. The cross section for resonant ρ^o production, $\gamma p \rightarrow \rho^o p$, is $11.2 \pm 0.1(\text{stat.})^{1.1}_{-1.2}(\text{syst.})\mu\text{b}$ at an average W = 71.7 GeV. It increases slowly with W, exhibiting a power-like behavior of the type W^α with $\alpha = 0.16 \pm 0.06(\text{stat.})^{0.11}_{-0.15}(\text{syst.})$, consistent with $\alpha \cong 0.22$, the value expected for a "soft'" Pomeron. Figure 4 shows the cross section versus W for the present measurement as well as low energy data obtained in fixed target experiments.

v) *Event Shape Analysis of Deep Inelastic Scattering Events with a Large Rapidity Gap*

A global event shape analysis of the multihadronic final states observed in neutral current deep inelastic scattering events with a large rapidity gap with respect to the proton direction is presented. The analysis is performed in the range $5 < Q^2 < 185\,\mathrm{GeV}^2$ and $160 < W < 250\,\mathrm{GeV}$. Particular emphasis is placed on the dependence of the shape variables, measured in the γ^*-pomeron rest frame, on the mass of the hadronic final state, M_x. Results are shown in Figure 5. With increasing M_x, the multihadronic final state becomes more collimated and planar. The experimental results are compared with several models, which attempt to describe diffractive events. The broadening effects exhibited by the data require in the models a significant gluon component of the pomeron.

b. HERA and ZEUS Operations

After the highly successful run of 1997, the machine shut down in November to install the remainder of the new vacuum pumps necessary for electron operations. The installation was completed in June and no leaks were found. Additional machine upgrades, such as new p-ring power supplies and a new HERA control system are expected to improve the machines duty cycle.

The ZEUS collaboration took advantage of the longer shut down period to install several new components into the detector:

1. The installation of the Barrel Presampler was completed with the insertion of all 32 scintillator cassettes. With the completion of the Barrel Presampler, the entire high-resolution calorimeter is covered with preshower detectors.

2. The Forward Plug Calorimeter was installed to extend the calorimeter coverage in the very forward region. This new calorimeter required, in addition, the installation of a new beam pipe with a significantly reduced diameter.

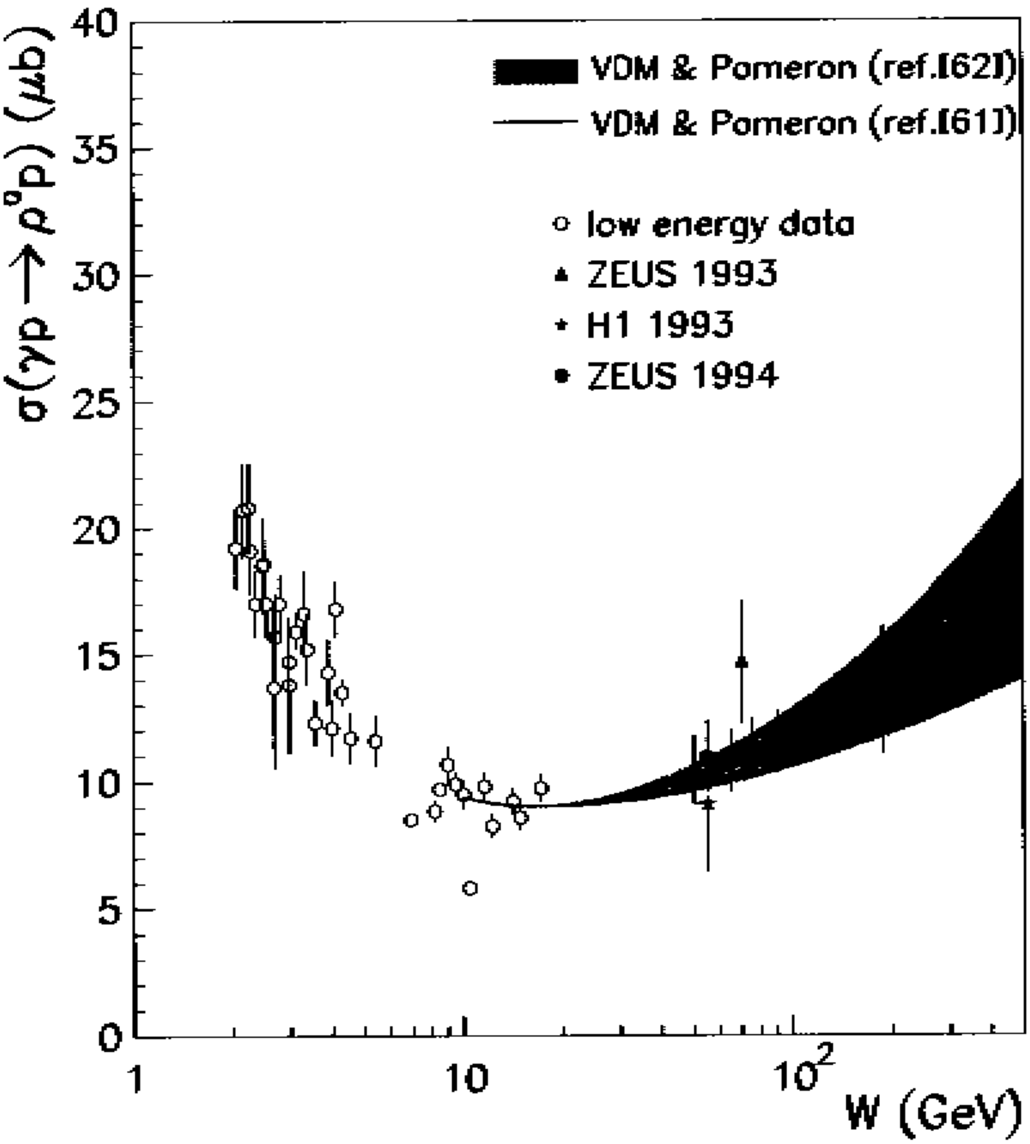


Figure 4. The integrated cross-section $\sigma_{\gamma p \rightarrow \rho^o p}$ as a function of the center-of-mass energy W. The ZEUS results are given for the range $2M_\pi < M_{\pi\pi} < M_\rho + 5\Gamma_0, |t| < 0.5 \mathrm{GeV}^2$. The other results from HERA and a compilation of low energy data, are also shown. The continuous and dashed line are parameterizations based on Regge theory which assume the value of the pomeron intercept found by Donnachie and Landshoff and by Cudell, *et al.*, respectively. The band corresponds to the uncertainty in the determination of the pomeron intercept. The error bars of the ZEUS points indicate the sum of statistical and systematic uncertainties in quadrature. For the points at the same value of W, the error bars have been offset.

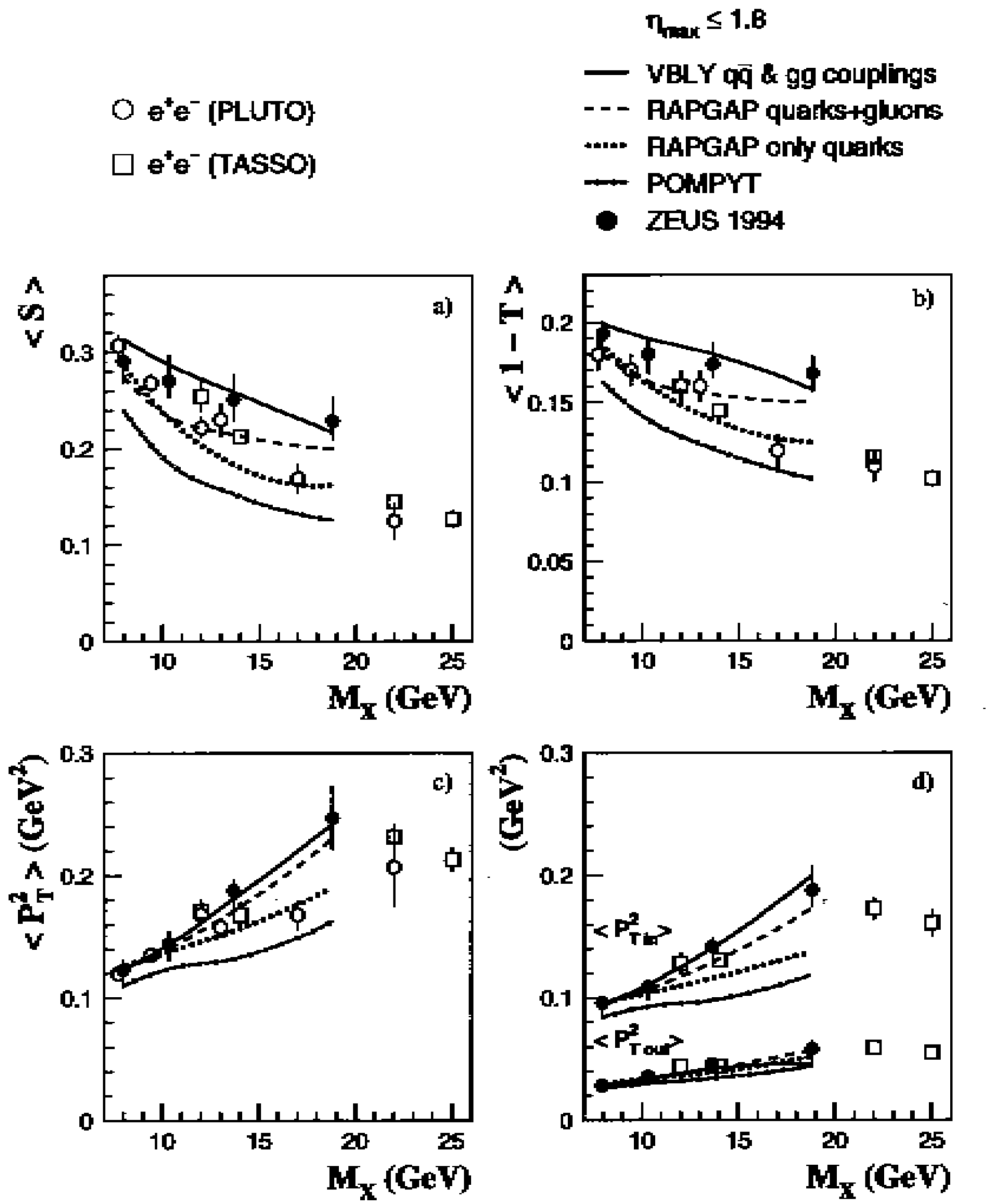


Figure 5. The mean sphericity, one minus mean thrust, mean squared transverse momenta w.r.t. the sphericity axis and its components in and out of the event plane, plotted as a function of M_x. Open dots and squares represent PLUTO and TASSO measurements at DORIS and PETRA, respectively. Black dots represent the ZEUS data corrected for detector effects to the kinematic region $5\ GeV^2 \leq Q^2 \leq 185\ GeV^2$, $160\ GeV \leq W \leq 250\ GeV$, and $\eta_{max} \leq 1.8$. Note that the ZEUS data and the predictions from the models are for $\eta_{max} \leq 1.8$.

3. The installation of the Forward Hadron-Electron Separator (FHES) was completed during the shutdown. The FHES will provide a powerful tool to identify the scattered electrons of very high Q^2 events and to identify prompt photons in the forward region.

4. The Forward Neutron Calorimeter was equipped with a position sensitive detector. This addition will result in a better understanding of the geometrical acceptance and, thus, to the reduction of systematic errors.

(J. Repond)

I.A.5 BNL AGS Experiment to Overcome Intrinsic Resonances

Earlier we reported successful performance of the RF dipole magnet to overcome intrinsic resonances.

At the injection energy into RHIC, the beam polarization was about 40% at 21.7 GeV. In order to achieve higher beam polarization, we need to overcome a new type of spin depolarization resonance observed at the BNL AGS. The strength of the resonance was proportional to the 9th harmonic component of the horizontal closed orbit distortion, as well as the vertical betatron oscillation amplitude. To overcome this new type of resonance, the horizontal closed orbit distortion needs to be corrected using harmonic correctors. This procedure which uses harmonic correctors to correct the imperfection resonances by correcting the vertical closed orbit, is the same procedure we used in the old days.

(A. Yokosawa)

I.B EXPERIMENTS IN PLANNING OR CONSTRUCTION

I.B.1 Polarized Beam Experiments for a RHIC Polarimeter

Results of the E-925 experiment, asymmetry measurements in the inclusive reaction pC $\rightarrow$ $\pi^{\pm}$ + X using the 22 GeV extracted polarized proton beam from the AGS, have been analyzed. We are trying to understand and solve several inconsistencies among runs. The preliminary results indicate a nice resemblance to the Fermilab 200-GeV data where π^{+} and π^{-} show a mirror symmetry with respect to x_F at p_T > 0.7 GeV/c in pp $\rightarrow \pi^{\pm}$ + X. A paper on the E-925 measurements has been prepared.

1.a. *POLARIZED BEAM*

Collaborated in achieving the highest energy accelerated polarized beam at AGS, to be used for RHIC injection. (Phys. Rev. Lett.)

1.b. *POLARIMETERS*

Lead in designing, building, and running E925 pion inclusive experiment. (To be published.)

(A. Yokasawa)

I.B.2 STAR Detector for RHIC

Argonne has been successful in terms of getting the barrel Calorimeter for the STAR experiment approved and provisionally funded, and in terms of numerous studies and physics experiments to establish the polarized beams and ways of utilizing polarized beams in STAR and other experiments.

Unfortunately, Argonne has been effectively eliminated from the barrel calorimeter project. It had been surmised since early 1996 that ANL could not compete with Wayne State U. for the mechanical assembly jobs since they had labor rates one-half of Argonne's and also got $2.5 to $4 million dollars in subsidy. In late 1997, the Division agreed to refocus on electronics jobs. In retrospect, it was basically too late and the engineering resources available from the division were far too limited to compete with LBL.

These factors are in addition to the conflict between Nuclear and High Energy physicists and agencies. The STAR EMC management clearly wanted to eliminate high energy physics people from the project and the HEP division was never really comfortable with work labeled as Nuclear physics.

We did a good job while we were involved:

a. *PHYSICS LEADERSHIP*
1. Coordinating RHIC SPIN activities (spokesman)
2. STAR Physics Analysis Coordinator
3. Numerous STAR notes on Spin Physics and techniques

b. *STAR MANAGEMENT*
1. Spreadsheet
2. Cost estimates
3. Electronics

c. *STAR MECHANICAL*
1. Design of EMC support system
2. Installation of EMC support system
3. Installation test / demonstration
4. Design of installation system

d. *STAR ELECTRONICS*
1. Head of EMC electronics during early ‘98
2. Designed / built one of two shower max electronics systems for test beam ‘97
3. Worked out level 0 trigger methodology now adopted

An ANL person was until this summer the Head of physics analysis, coordination the efforts of all the physics sub-groups and the computing effort.

An ANL person was, until May, a member of the EMC electronics planning group of 5 people who met several times in the past year to plan the trigger and calorimeter readout. During part of the last year he was head of the EMC electronics, and did planning for work and funding, as well as electronic design work along with the engineers at ANL, Rice, MSU, and LBL.

There was considerable work at ANL on developing work and funding plans. Some parts of these were included in the MOU, which was written with the expectation of a substantial Argonne role in the barrel calorimeter.

The scheme for the EMC level 0 trigger that originated at Argonne has served as the basis of the current trigger design, although with some downgrading of capability for financial reasons.

The HEP mechanical engineer worked on design of installation fixtures for the calorimeter and its supports. The supports have been installed successfully.

Argonne also led the discussions and work on the luminosity monitor issues required to measure extremely small spin asymmetries in a collider. This has involved both accelerator and detector issues.

At present, discussions are continuing concerning the participation of Argonne in the Encap Electromagnetic Calorimeter. This calorimeter is essential for the High Energy spin physics. It is anticipated that this can be funded by NSF and DOE NP.

(D. Underwood)

I.B.3 MINOS - Main Injector Neutrino Oscillation Search

The MINOS experiment is designed to search for neutrino oscillations with a sensitivity significantly greater than has been achieved to date. The phenomenon of neutrino oscillations, whose existence has so far not been proven convincingly, allows neutrinos of one “flavor” to slowly transform themselves into another flavor, and then back again to the original flavor, as they propagate through space or matter. The MINOS experiment is optimized to explore the region of neutrino oscillation parameter space (values of the Δm^2 and $\sin^2(2\theta)$ parameters) suggested by previous investigations of atmospheric neutrinos: the Kamiokande, IMB, Super-Kamiokande and Soudan 2 experiments. The study of oscillations in this region with a neutrino beam from the Main Injector requires measurements of the beam after a very long flight path. This in turn requires an intense neutrino beam (produced by the new Fermilab Main Injector accelerator) and massive detectors. The rates and characteristics of neutrino interactions are compared in a “near” detector, close to the source of neutrinos at Fermilab, and a “far” detector, 730 km away in the underground laboratory at Soudan, Minnesota. The neutrino beam and MINOS detectors are being designed and constructed as part of the NuMI (Neutrinos at the Main Injector) Project at Fermilab.

The MINOS detectors are iron-scintillator sandwich calorimeters, with toroidal magnetic fields in their thin steel planes. The combination of alternating active detector planes and magnetized steel absorber planes has been used in a number of previous neutrino experiments. The MINOS innovation is to use scintillator with sufficiently fine transverse granularity (4-cm wide strips), so that it provides both calorimetry (energy deposition) and tracking (topology) information. The 5,400 metric ton MINOS far detector is also much more massive than previous experiments. Recent advances in extruded scintillator technology and in pixilated photomultipliers have made such a detector feasible and affordable for the first time. A sketch of the MINOS far detector is shown in Figure 1.

In early 1998, the Super-Kamiokande experiment presented results on the zenith angle distributions of atmospheric neutrino interactions, which strongly supported earlier evidence for neutrino oscillations. The new data confirmed indications that muon neutrinos oscillate into tau neutrinos or sterile neutrinos, but not into electron neutrinos. The new data also confirmed that oscillations might occur with much lower values of Δm^2 (down to 5×10^{-4} eV^2) than suggested by the results of the earlier Kamiokande experiment. This possibility had already motivated the MINOS Collaboration to begin an intensive program to optimize the low Δm^2 sensitivity of the experiment in 1997. This led to the design of a more flexible neutrino beam, which could give useful neutrino flux down to 1 GeV. Figure 2 shows that this PH2(low) neutrino beam design does allow the MINOS experiment to study the very low Δm^2 region suggested by the Super-Kamiokande results.

In May 1998, a special MINOS Subcommittee of the Fermilab PAC reviewed the physics goals and the scientific capability of the NuMI-MINOS project in light of the new Super-Kamiokande results. The Subcommittee concluded that "there now appears to be a respectable body of evidence indicating the existence of neutrino oscillations," and expressed the feeling that "it is more desirable than it was even a few years ago to go ahead with a strong long-baseline neutrino oscillation program at Fermilab." The Subcommittee's report was strongly endorsed by the Fermilab PAC at its June 1998 meeting: "The compelling evidence for neutrino oscillations that has developed over the past year, primarily from the Super-Kamiokande experiment, makes a confirmation and study of this phenomenon an important and exciting area of research. Fermilab is well-positioned to take a leading role in this effort, and the NuMI/MINOS program should be pursued with high priority. The Committee believes the MINOS priority should be second only to Run II at this time."

The MINOS Collaboration, and the Argonne MINOS group, devoted most of its effort during the first half of 1998 to preparing a Technical Design Report (TDR) and a Cost and Schedule Plan (CSP) for the NuMI-MINOS Project. The documents describe the engineering design, cost estimate and schedule of the experiment in detail, and are required for the DOE "Baseline" Review of the project, which is scheduled for late 1998. Draft versions of the MINOS TDR and CSP were presented to a special Fermilab Director's Review of MINOS in April 1998. The committee concluded that the technical design of the experiment was well matched to its physics goals. The found no technical "show stoppers" and said that the Collaboration had made a good start on the cost estimate and schedule preparation for the DOE Baseline Review. The committee also expressed concern that the light output of the scintillator system must still be shown to be adequate.

The second major focus of work by the Argonne MINOS group, after preparation for the NuMI-MINOS Project reviews described above, was the engineering design and prototyping of critical parts of the scintillator detector system. Argonne physicists and engineers serve as NuMI Project Level 3 WBS Managers for the scintillator strip fabrication and for the design and construction of the machines needed to construct scintillator modules. Prototype polystyrene scintillator strips extruded by a commercial supplier, Quick Plastics, were evaluated at Argonne and several variations on the extrusion conditions were tried in order to improve light output and reduce cost. The Argonne group also continued work on a prototype production facility for scintillator "modules" in Building 366. Modules are panels of 20 or 28 4-cm wide scintillator strips, which are packaged for easy handling and shipping. During the first half of 1998 the group's work focused on the development of optical fiber gluing and routing techniques, module light cover design and the design of an automated device for mapping the response of modules using a rapidly moving radioactive source.

Argonne MINOS group members also serve as WBS Level 2 managers for electronics and for far detector installation. During the first half of 1998 they continued to work closely with the Oxford and Rutherford groups to define the parameters of the baseline electronics design. Responsibility for the final design and fabrication of the MINOS electronics system will be shared between the Argonne and UK groups. Far detector installation work during this period involved close interaction with the architect engineering firm, CNA Consulting Engineers, which is designing the new MINOS cavern at Soudan, including its infrastructure and the detector support structure. During the first half of 1998 this work focused on the preparation of the "MINOS Far Detector Laboratory Design Development Report" which describes the detailed technical specifications for the civil construction work. The Argonne installation group also continued to work on the design of installation procedures for the detector at Soudan, in close collaboration with the Soudan 2 mine crew and with CNA.

Finally, Argonne physicists and engineers were heavily involved with the initial preparations for MINOS excavation work at Soudan. A program of test blasts was conducted in the spring of 1998 to determine the effect of MINOS blasting on Soudan 2 detector modules and other existing structures. The new MINOS cavern will be constructed immediately adjacent to the operating Soudan 2 detector. Since the MINOS Collaboration plans to use the Soudan 2 detector as a fine-grained complement to the new MINOS far detector in the search for neutrino oscillations, it is very important that the existing detector is not damaged by the vibrations and shock waves from blasting during the MINOS cavern excavation. The test blasts showed that such damage could be avoided if proper precautions are taken, for example limiting the size of explosive charges and using blast doors to prevent air shock waves from reaching the Soudan 2 detector. These precautions are not expected to increase the cost or affect the schedule of the MINOS cavern excavation. Also during the first half of 1998, preparations were started for moving the Soudan 2 cavern utility lines (gas, electrical power and data lines) away from the East walls of the entrance and the main cavern, where the entrance tunnels into the MINOS cavern will be located.

(D. S. Ayres)

I.B.4 ATLAS Detector Research and Development

a. Overview of ANL LHC Related R&D Programs

The US ATLAS collaboration realized a key project milestone in the first half of 1998: the project went through a joint DOE/NSF baseline review and was approved to proceed with construction of the detector. In addition, in Europe the fabrication of mechanical components began and in this period the US manufactured die was used to stamp all 41,000 master plates required for the barrel calorimeter.

(J. Proudfoot)

I.C DETECTOR DEVELOPMENT

I.C.1 CDF Detector and DAQ Electronics Development

a. Upgraded Shower Max Readout Electronics

John Dawson's prototype VME digital readout board for shower maximum and related detectors ("SMXR") was tested with prototype SMD front end cards and digital fake versions of Gary Drake's "SQUID" daughterboards. After some fixes, the system worked and data transfer was robust. The current version in the development of the SMQIE shower max digitizer ASICs being used for tests in our shower max chamber test stand, using SQUID prototypes, by Karen Byrum and Steve Kuhlmann. The scheme of using current calibrations to get gains and offsets for the various ranges of the SMQIE does not work well with the current chip, but the next generation SMQIE has design changes to the splitter transistor bias which should fix the problem. A working system would help Gary in the development of the difficult low noise amplifiers needed by the wire chambers for SMQIE input.

Karen, working with John Dawson, is developing a receiver for the level 2 trigger system to accept the information from SMXR, working with the University of Michigan level 2 people. Bob Blair, Steve Kuhlmann and John Dawson are working on the photon/electron trigger isolation hardware, also with the Michigan group. Jimmy Proudfoot is working with Jim Schlereth to develop the electronics test stand software, which may evolve to be usable in the online environment.

b. CDF Central Tracking Chamber Replacement

Randy Keup, working with Vic Guarino, Emil Petereit and Larry Nodulman, put together bid packages and shop estimates for the design for production tooling for inserting wire planes and field sheets into the new CDF central tracker "COT." Randy also continued working with David Kazhins at Fermilab on the COT prototype and using it to solve various problems in electrostatic and gravitational deflections for the field sheets and wire planes and assembly quality control.

(L. Nodulman)

I.C.2 ZEUS Detector Upgrade

a. Barrel Presampler (BPRE)

During the months of January and February, all 32 BPRE modules were installed by S. Chekanov, C. Keyser, L. Kocenko, S. Magill, and R. Stanek from ANL along with J. Hauschildt and K. Loeffler from DESY. Each module was loaded into the space between the solenoid cryostat and the front face of the BCAL at the bottom of the detector, then pulled into position by steel cables. After installation, the LED was flashed and the ends of the fiber bundles were checked to ensure no damage occurred during shipping or installation. All modules were tested successfully. After the installation was complete and the modules were aligned into position, the fiber bundles were routed through the space between the BCAL rear plate and the spokeswheel to the T-beam area of the BCAL where the PMT housings were located. The cables for the LED system were installed, and cabling for the HV system was installed. A delay in obtaining signal cables (ordered by DESY), resulted in installation of the signal cables to be postponed until July 1998.

The new HV system was developed at ANL and shipped in time for installation by June 1998. The whole system was installed, but during testing, 5 modules worth of BPRE bases were damaged by a short in the HV supply. The bases are repairable and have been returned to ANL for repair, to be re-installed in August 1998.

The analog readout system was also installed during this time (but not hooked up with the BPRE due to the signal cable delay). Electronics testing of the analog cards showed that all cards work as designed. The digital cards were installed in the Rucksack and tested. The full readout system, including analog and digital readout, was tested and is ready for data-taking and calibration runs.

In summary, during this period, the BPRE was installed and made ready for data-taking to begin in August 1998. Still to be done before August is to install the signal cables, fix 5 modules worth of PMT bases (~ 60 total), and to generate calibration constants for the readout electronics.

(S. Magill)

I.C.3 ATLAS TRIGGER DEVELOPMENT

a. ATLAS Level 2 Trigger

The trigger for the LHC ATLAS experiment will use a novel approach to reducing the amount of data used in making trigger decisions. It uses the regions defined by early hardware processing (done by a fast *level 1* trigger) to guide what data is used at the next level for the decision. This next level, *level 2*, is expected to be done using data only from the *regions of interest*, ROI's, defined by the *level 1* trigger. The information about these ROI's has to be collected from the *level 1* system and passed to other parts of the ATLAS trigger. Argonne and Michigan State University are collaborating to provide the hardware and software that will achieve this. This system is called the Supervisor, ROI builder (SRB).

The ATLAS trigger architecture is currently being decided on. During the beginning of 1998 the ATLAS *level 2* group has begun setting up a pilot system to evaluate the suitability of current technologies for use in the level 2 trigger. Argonne is involved in three areas of this endeavor. A farm of 12 Intel based PC's and 4 VME based processors is being set up with an ATM (Asynchronous Transfer Mode) switch which will allow benchmarking of processor algorithms and communications. This small sixteen node system will be combined with similar size systems at Saclay and at CERN to make a test system with 48 nodes early next year.

In addition to communication and algorithm benchmarking, the beginnings of the overall software framework for the ATLAS level 2 trigger is being assembled. This will start out as a program that will run on a single processor but that will be able to be distributed across many computers in a distributed system like that envisioned for the ATLAS trigger. This is being done with care to rely on modern software engineering practices. The code design has begun. After an initial design, an independent review team will review the design before any of the code is written. Argonne is responsible for the part of the code that involves the level 2 supervisor and its interface to the level 1 system.

A conceptual design of the device that assembles the information from the level 1 system and sends it to a supervisor processor has begun. This is referred to as the level 1 ROI builder. The level 1 trigger will deliver information about the trigger decision and the ROI's used to form it from 12 independent sources As currently conceived the ROI builder will take these 12 inputs using a communication standard referred to as S-link and combine the 12 separate pieces of information for each subsystem for a given event into a single S-link transmission to one of a number of ROI processors. In this way the processing and I/O overhead for the ROI processors that communicate with the rest of the level 2 system will be greatly diminished.

(R. Blair)

I.C.4 ATLAS Calorimeter Development

In this period work continued on development of plans for the construction of the calorimeter and on review of critical engineering design data. In particular, the design of the main support element—the girder—was reevaluated in terms of weld type and anticipated structural loads. A final design decision was not made in the period covered by this report, however no deficiencies were found in the improved design. Finally, substantial effort was spent in developing plans and procedures as a basis for the construction effort. These three areas are addressed in more detail below.

a. Structural Design and Analysis

a.1 *Girder Design*

The welds used in the earlier version of the support girder were deemed to be inappropriate for the structural role of this component. The design was modified to be in compliance with the necessary engineering codes and re-analyzed by Argonne engineers using the original finite element model. This result was combined with similar analysis and calculation done in Europe to assure the collaboration that this element was in principal capable of accommodating the maximum gravitational load plus the required load from seismic effects. A final decision on this design is scheduled for September 1998, by which time it is hoped that load tests of a test section of girder will have been carried out. However, no untoward results are expected and this change in the design is not expected to delay procurement of this piece.

a.2 *Inner Cryostat Support*

The conceptual design for the inner supports for the liquid argon endcap calorimeters was documented and distributed to both the Tile Calorimeter engineers and the cryostat engineering group. As part of this design effort, the Argonne group investigated several types of jacks, which might be appropriate for use in this support. ANL has developed a conceptual design of a combined two-jack support, based upon a commercially available single jack. This is shown in Figure 1. One such jack was identified as a good candidate and was investigated further, when it became apparent that a pair of jack cylinders would be required.

Two of these jacks were bought at the expense of CERN, and will be used for further evaluation in the second half of 1998.

(V. Guarino, J. Proudfoot)

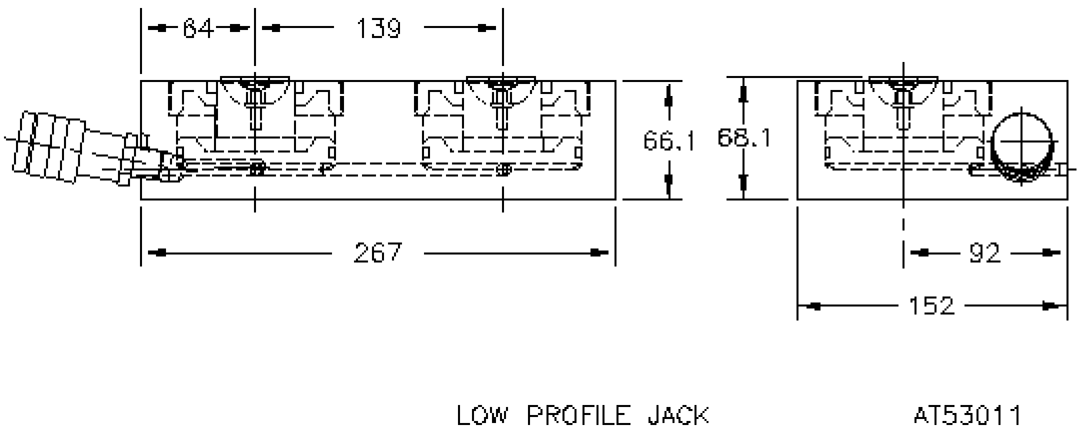


Figure 1. Conceptual design for low profile, tandem jack to be used in the inner support of the endcap cryostat.

b. Calorimeter Construction

Initial component fabrication began in this period in Europe with stamping of all 41,000 master plates needed for the barrel calorimeter. In addition, two key procurements were placed in the US in preparation for start of submodule assembly at the beginning of 1999.

b.1 *Barrel Master Plate Production*

The die fabricated in the US and used for stamping of the prototype master plates was shipped to CERN in late 1997. Die certification for production of the barrel masters was carried out in March 1998. An Argonne engineer traveled to the stamping plant near Ostrava in the Czech Republic to participate in this critical test and to confirm that the die was set up correctly. This was indeed the case, with the parallelism of the two-die surfaces being determined to be within 0.4mm. The die was successfully re-sharpened after stamping 18,000 plates, which in itself demonstrated the technical expertise of the vendor selected to perform this work. The performance of the die was carefully monitored throughout production. Of central importance are the widths of the outer- and inner-radius keys. This is shown in Figure 2 for the 79 plates measured to high precision on a computer measurement machine. The small number of plates which fall below the nominal tolerance were deemed to be of no significance, when reinspection and visual inspection indicated that the most likely cause was small burrs on the edge of the key. The 41,000 plates were stamped in a four-month period, with the production rate wholly determined by rate at which raw steel sheet could be procured.

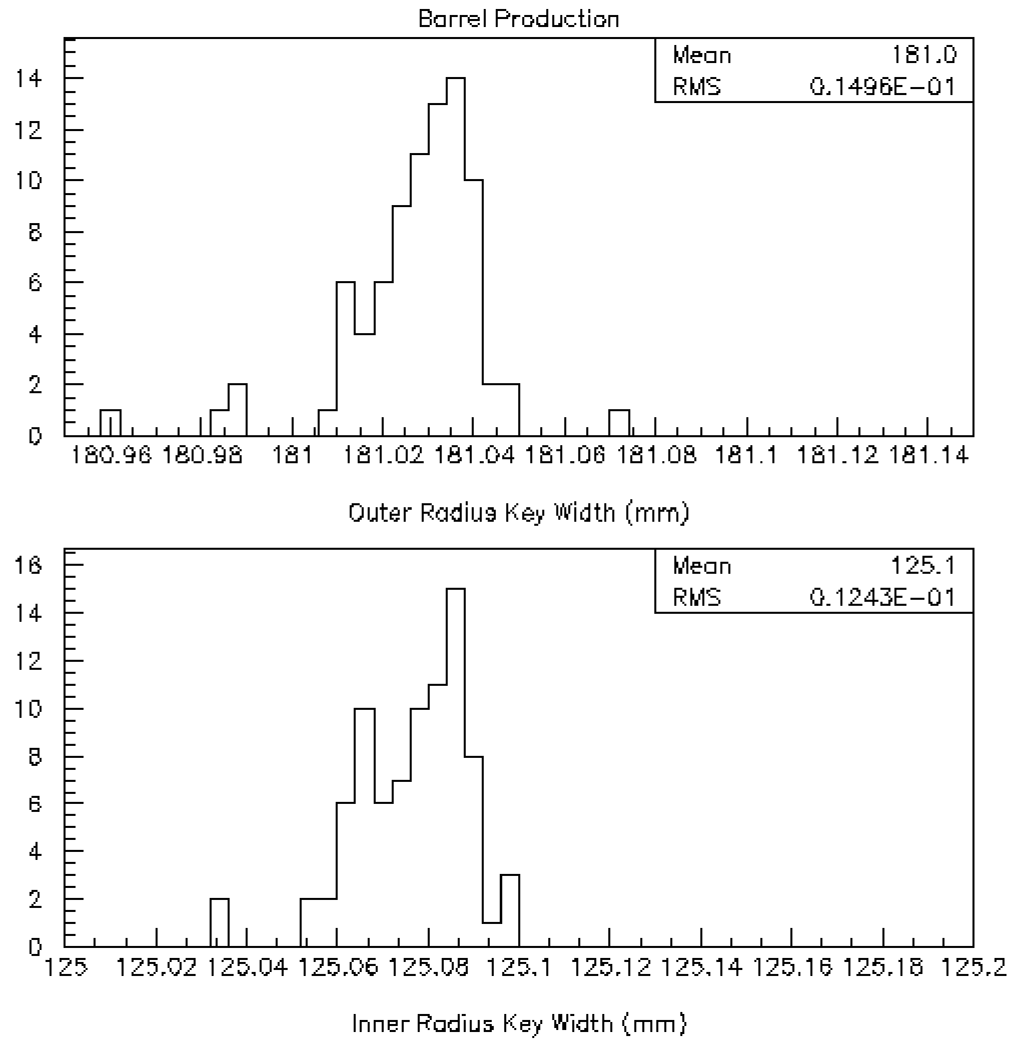


Figure 2. Master plate production quality control data for inner and outer radius key widths.

b.2 *US Master Plate Steel Procurement*

Considerable effort was expended in effecting a common steel specification, which could be used for both a European, and US tender. Eventually, the specification for the barrel steel was used with some minor modifications. The low bidder from the tendering process was the steel supplier used for the barrel steel, exercised through a CERN contract option and was accepted. The order was placed in May 1998 and steel delivery is expected to begin in September 1998.

b.3 *US Master Plate Stamping*

Following the selection of a European steel supplier, it was decided to carefully consider using the same vendor to stamp the extended barrel master plates as was used for stamping barrel master plates (ZTS, Dubnica). The basic stamping cost at this vendor was significantly below what was expected from a stamper in the US and the only serious issue was that of the expected increase in shipping costs. Several estimates for plate shipping were obtained, from which we determined that this was in fact the most cost effective solution. Following a visit by L. Price to the stamper to meet and discuss issues, the contract was placed in June, with delivery of the first master plates in the US expected in October 1998.

b.4 *Module Shipping*

Falling somewhere between a design task and construction preparation task is the task of better defining the scheme by which modules will be shipped to Michigan State University (MSU) and in the case of instrumented modules, to CERN. Significant effort was expended in understanding the constraints of moving modules in and out of the instrumentation area to be used at MSU. Eventually, following the recommendation of Argonne staff, the MSU group has agreed to base their handling scheme on a simple cart (rather than an airbed skid as they had initially planned). Argonne provided the basic design of this cart, following a similar fixture built for moving ZEUS modules, and the design is now being carried forward by the Michigan group.

Module shipping to CERN is one of the remaining issues that must be fully addressed in 1998. In the first half of this year a conceptual study was done using the Argonne shipping broker, from which it was determined that it would be feasible to ship pairs of modules in a standard shipping container. Some work was also done to understand the ways in which modules could be loaded into such a container, blocked in for shipping and protected from moisture. A conceptual scheme for how this can be accomplished was identified. This will be used as the basis for tendering of the shipping contract at which time the exact details will need to be worked out in collaboration with the vendor selected.

b.5 *Building Preparations in 366*

Building 366 at Argonne is the location where all of the calorimeter construction and instrumentation is to take place. A large fraction of this floor area is required and, in the first half of 1998, most of the remaining housekeeping needed to provide this space was carried out. This work was mostly disposal of unneeded hardware and materials, or in the case of useful equipment, its removal to other storage areas on site.

b.6 *Calorimeter Instrumentation*

Some general preparation for module instrumentation was begun in this period. The first comprises the straightforward assignment of building space and storage facilities as required to carry out this task. In addition, an optical test module consisting of a shortened stack of master and spacer plates was constructed. This has all the mechanical and optical features of a standard submodule with the exception that the stack is held together using bolts (much like the very early design of a submodule). At the present time, the mechanical structure has been assembled including scintillator and source tubes in a light-tight box. The fibers and profiles required to complete the system are expected in the fall and, after initial tests at Argonne, it is intended to ship this system to MSU, where the bulk of the responsibility for the optical system is assigned here in the US.

b.7 *Project Management and Planning*

Significant effort was spent on developing project management tools in this period. The “Cost Book” and “Basis of Estimate” giving the total estimated cost of the calorimeter, was thoroughly gone over and presented to a DOE/NSF review committee in February 1998. The review panel concluded that the technical design and cost estimate of the calorimeter were sound and that the calorimeter should be approved to proceed with construction. The same was generally true for all other subsystems in ATLAS in which US groups are involved. Work also started in this period to refine the high-level schedule developed through the early work in the project into a more detailed schedule with which to manage the construction of the calorimeter.

(V. Guarino, J. Proudfoot)

c. Test Beam Program

The thrust of the current year's effort was two-fold: to understand the performance of the detectors which have been already mounted in the testbeam and, to re-instrument Barrel Module 0 and verify in a June testbeam run that the optics and electronics were of sufficiently good quality for production.

HEP staff took an active part in the ongoing analysis of the September, 1997 data from the extended barrel modules built by Barcelona and Argonne. Along with status reports on the subcomponents, one aspect of the analysis was requested to be presented to the ATLAS PRC in January. Since $\not{E}_T$ is sensitive to anomalously large energies in the calorimeter, we presented data showing that the events deviating from an expected gaussian should be inconsequential. For example, we can see in Figure 3 that there is one event at 6*s*, which deviates from the expected distribution. Similar events were found in the combined Tile-LAr data, and it is difficult to tell if these classes of events are fluctuations in the electromagnetic component of the shower, or perhaps two beam particles. The latter can be understood by looking at the FERMI samples in these events.

An offshoot of the analysis above is resulting in the understanding of the calorimeter response to electromagnetic and hadronic components of the hadron shower. The data shown in Figure 3 are obtained when one minimizes the resolution by weighting the transverse energy. HEP staff, in collaboration with the Czechs and Italians, are doing analysis to identify the hadronic and electromagnetic components. Preliminary results show promise in using this technique rather than an *ad hoc* H1 weighting algorithm.

It was thought that a poor resolution seen in the earlier combined Tile-LAr testbeam data at 20 GeV was due to proton contamination in the beam. However, results presented in an ATLAS Week showed in fact that pions had poorer response than did protons as seen in Figure 4. Interest in other hadron initiated showers was shown by the collaboration, and HEP supplied a second beam Cerenkov counter to try to understand better the beam particles. A recycled counter was fitted to a vacuum system and a CERN flange and installed in the H8 beamline at CERN.

In May, Module 0 was instrumented with good scintillator and two types of WLS fibers from both Bicron and Pol.Hi.Tech in Italy. Furthermore, the entire barrel module was equipped with readout electronics. 90 Hamamatsu R5900 phototubes were installed, along with 90 channels of bigain front-end electronics. HEP provided assistance to the collaboration's DAQ group with the readout of the drawers and the charge injection calibration. The bigain system worked well and the data are being analyzed.

In addition to the new bigain front-end electronics, Stockholm provided on-board digitizers mounted inside the drawers. Data were taken in the last few days of the June testbeam run. Data are sparse due to technical readout problems using the main RAID acquisition processor and a RIO processor controlling the timing and readout of the digitizers both situated in one VME crate. The new digitizer data are being studied.

(R. Stanek)

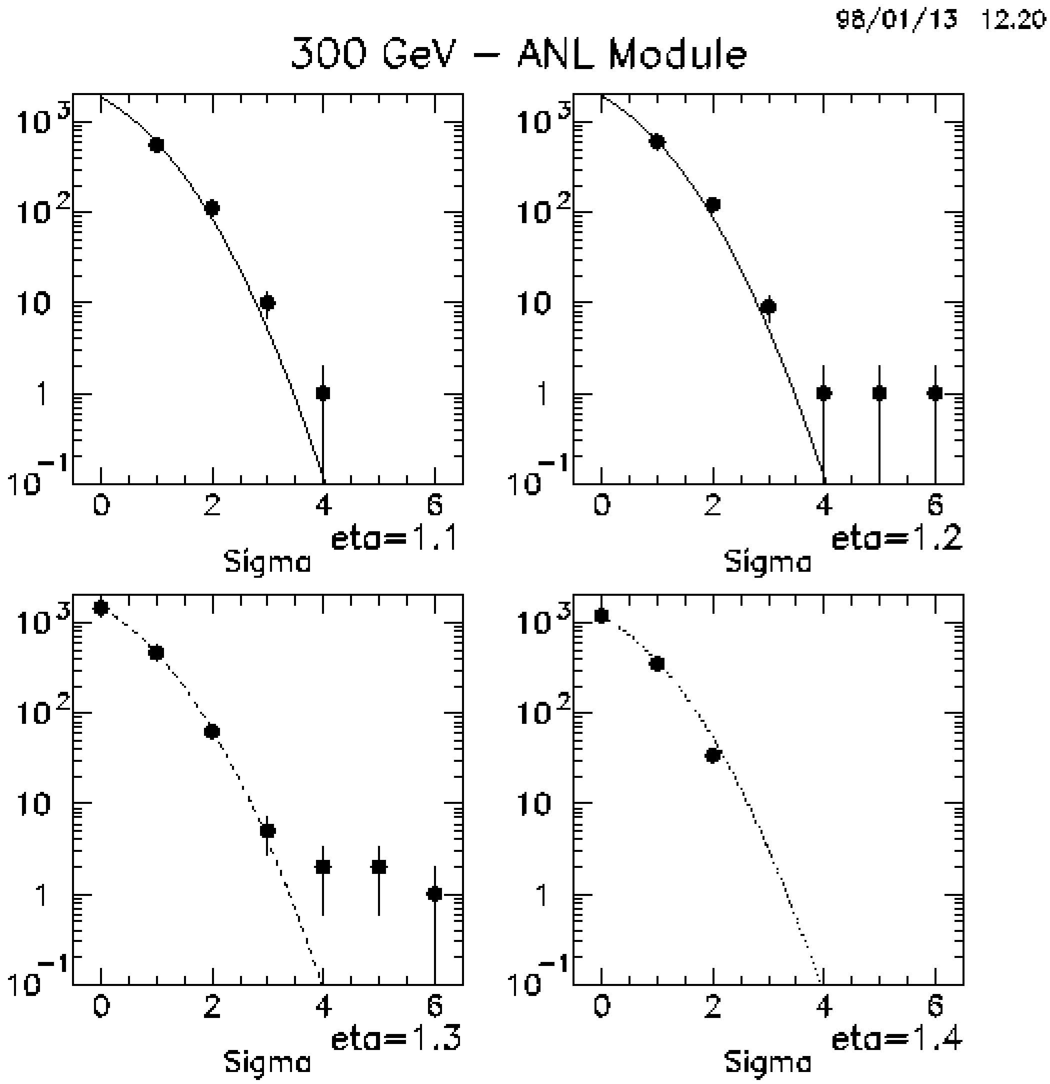


Figure 3. The number of events above N*s*, where *s* is the width of the gaussian parameterizing the response of the combined calorimeter setup (two extended barrels + prototype 1m module transverse catchers). The dashed line is the expectation from gaussian statistics. Shown are data from several impact points of the 300 GeV pion beam.

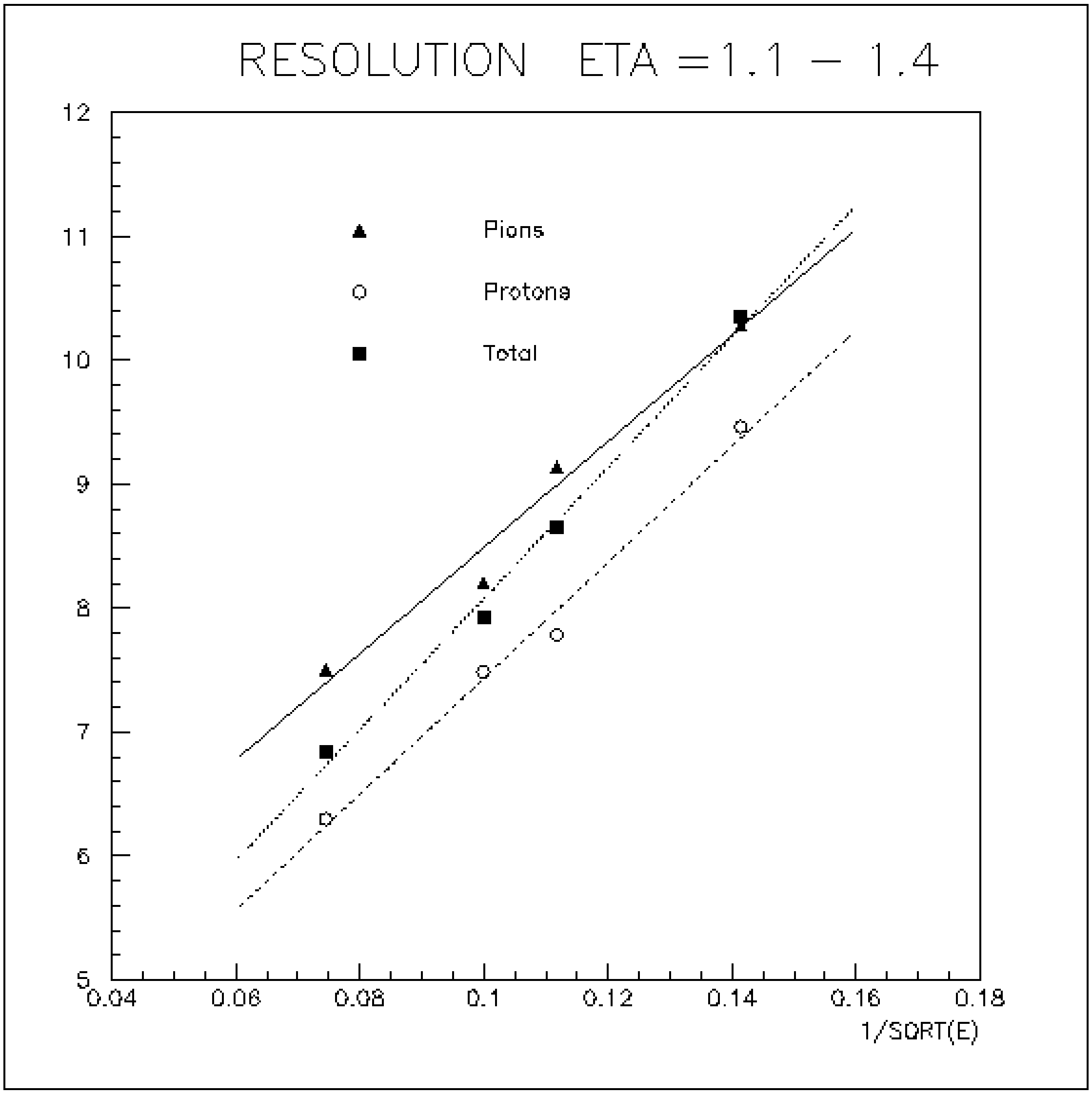


Figure 4. The resolution of the extended barrel setup as a function of beam energy for pions, protons, and the total, which depends on the *p/p* ratio in the beam at a given energy.

I.C.5 MINOS Detector Development

During the first half of 1998, the Argonne MINOS group devoted a substantial effort to the design and prototyping of critical components of the scintillator detector planes. Each of the 584 far detector planes is an 8-m wide octagon composed of 192 plastic scintillator strips. Figure 3 shows a sketch of one of these strips, which is extruded from polystyrene doped with PPO and POPOP fluors. The strip extrusions include a groove along the middle of one side into which a 1.2-mm diameter wavelength-shifting (WLS) fiber is glued. The strip extrusion is produced with a co-extruded outside layer doped with TiO_2 which provides a highly reflective outer surface. The scintillator strips are assembled into “modules” of 20 or 28 strips to simplify shipping, handling and installation. The array of strips is glued between thin aluminum skins and the WLS fibers are routed through manifolds to optical connectors. Each module contains a light injection manifold and a short radioactive source tube at each end for trouble shooting and calibration. Scintillator modules for the MINOS near and far detectors will be assembled from commercially supplied components at several “factories” operated by the Collaboration.

The Argonne MINOS group is responsible for the development of procedures for the production of extruded scintillator strips. Argonne physicists and engineers have worked closely with commercial suppliers to develop procedures for extruding strips with high light output, precise mechanical tolerances and low cost. The technique of coextruding the outer reflective layer of TiO_2 -doped polystyrene was developed by Argonne and Quick Plastics, the Michigan extrusion company which has produced nearly all of the prototype scintillator strips for MINOS to date. Another cost-saving innovation developed by Argonne and Quick Plastics is the “in-line” infusion process. Until now, extruded scintillator strips have been produced in two steps: first, the PPO and POPOP fluors are mixed with the polystyrene and extruded; later, these extrusions are remelted and extruded into strips of the final shape. The new in-line process mixes the fluors with the polystyrene and extrudes the strips in a single process, which reduces the cost significantly while maintaining the uniform mixing of fluors into the polystyrene.

The Argonne MINOS group is also responsible for developing most of the assembly machines, quality control equipment and procedures which will be used at the scintillator module assembly facilities. A major accomplishment during the first half of 1998 was the development of a semi-automatic machine for gluing the WLS fibers into the scintillator strip grooves and applying a thin strip of reflective material over the length of the fiber. Much effort was also devoted to optimizing the mechanical structure of the modules, which are 8-m long arrays of 20 or 28 scintillator strips laminated between aluminum skins. Prototypes were used to study the optimum amount of glue to use in the laminating procedure, and a vacuum compression technique was developed to flatten the modules during the glue curing step. Finally, the group devoted a substantial effort to the design of an automatic radioactive source scanning device called the “module mapper.” This device will be used to map the responses of completed scintillator modules just before they are packaged for shipping to the near or far detector site. The construction of a prototype module mapper was started at Argonne in early 1998. Figure 4 is a photograph of the laminating procedure used to produce prototype modules in Building 366. Figure 5 is a close-up view of the 20 WLS fibers in a module end manifold, which guides the fibers to the fiber optics connector. During the early summer of 1998, the first full-size prototype modules were produced at Argonne and shipped to Fermilab for testing.

(D. S. Ayres)

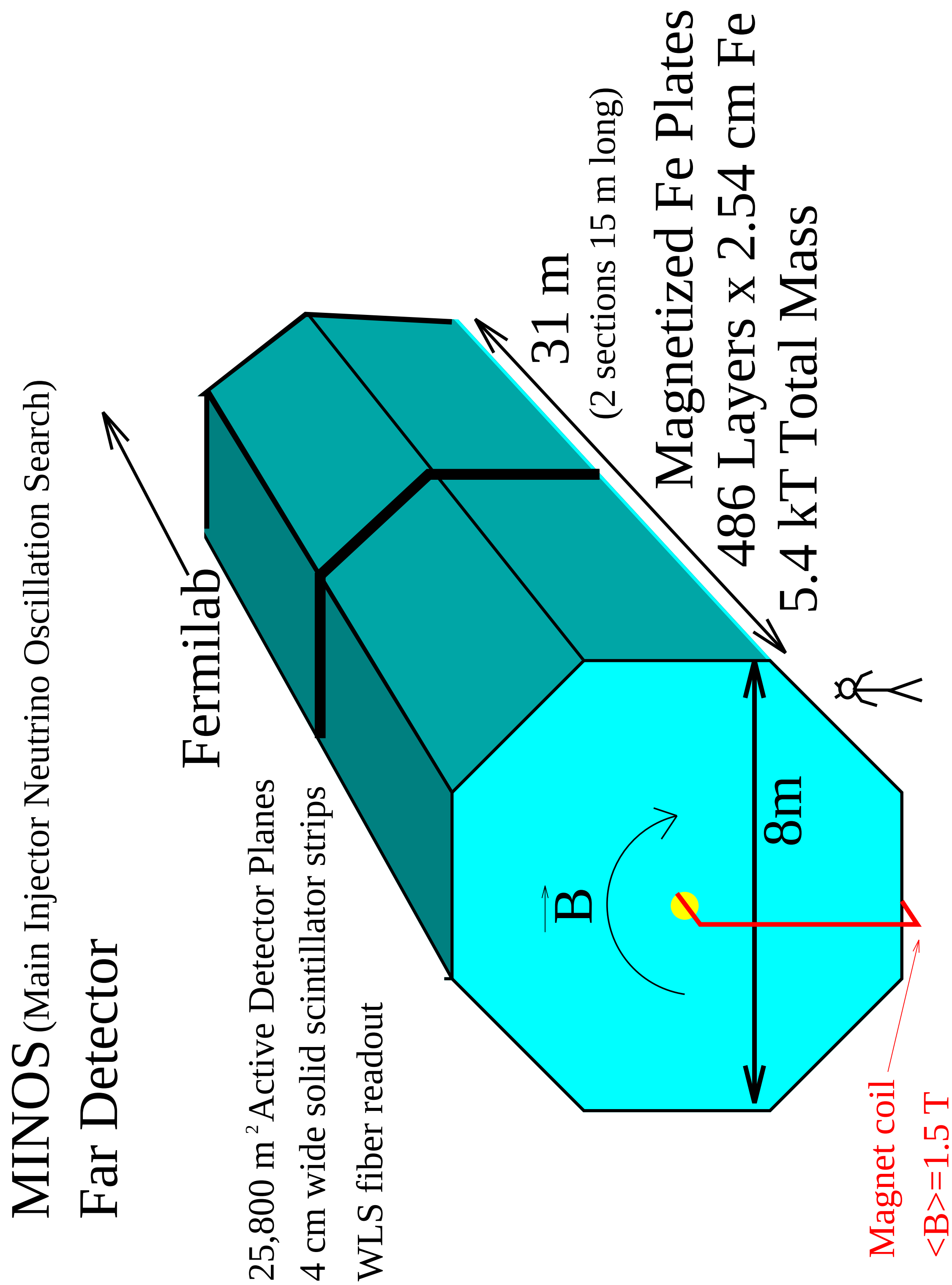


Figure 1. Sketch of the 5,400 metric ton MINOS far detector at Soudan. The detector is constructed as two identical "supermodules," each with its own magnet coil.

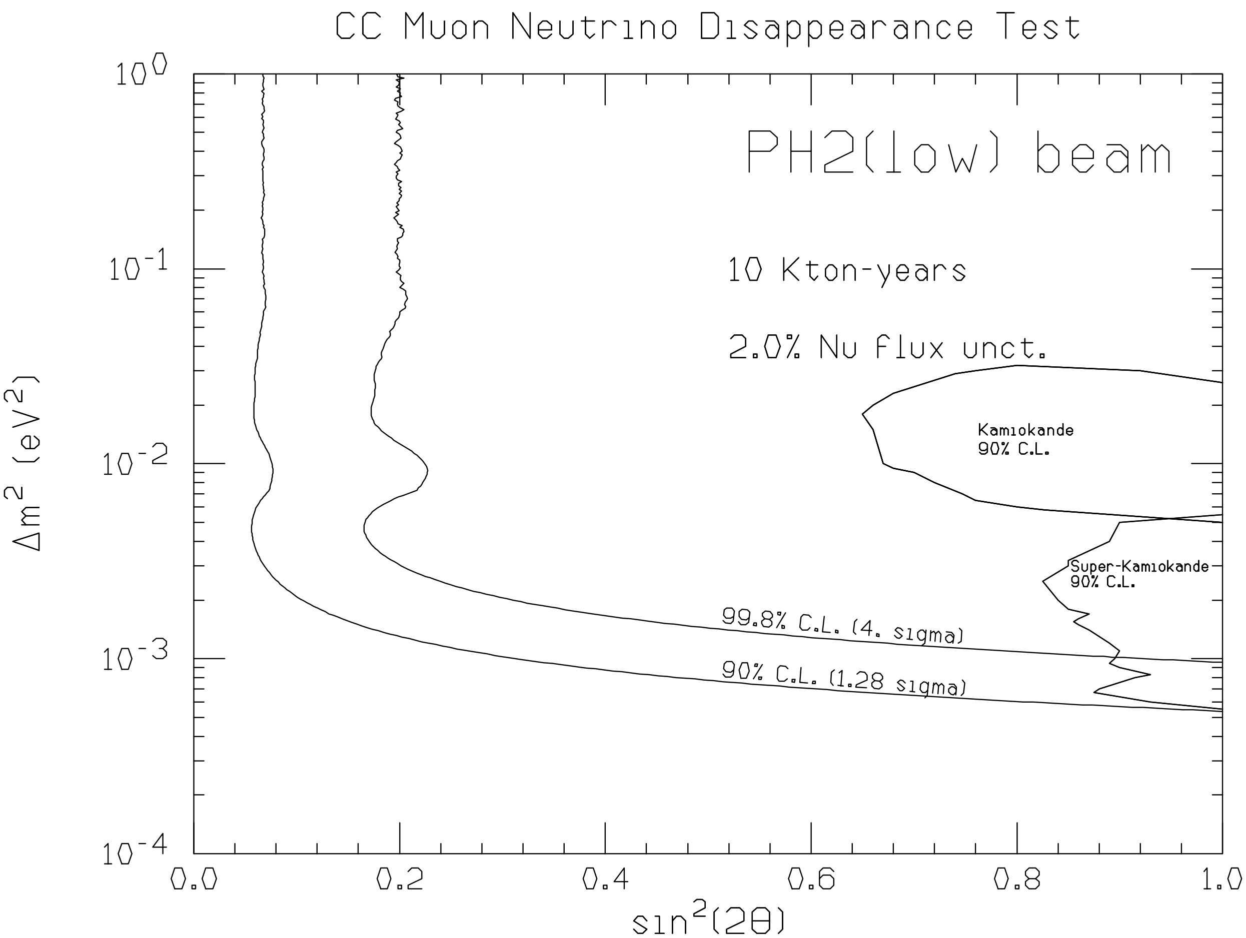


Figure 2. Sensitivity of MINOS to neutrino oscillations using the ν_μ disappearance test (90% CL limits and 4 sigma contour) for a 10 kton-year exposure in the low energy PH2(low) neutrino beam. The neutrino oscillation parameter space regions suggested by the Kamiokande and Super-Kamiokande experiments are shown for comparison.

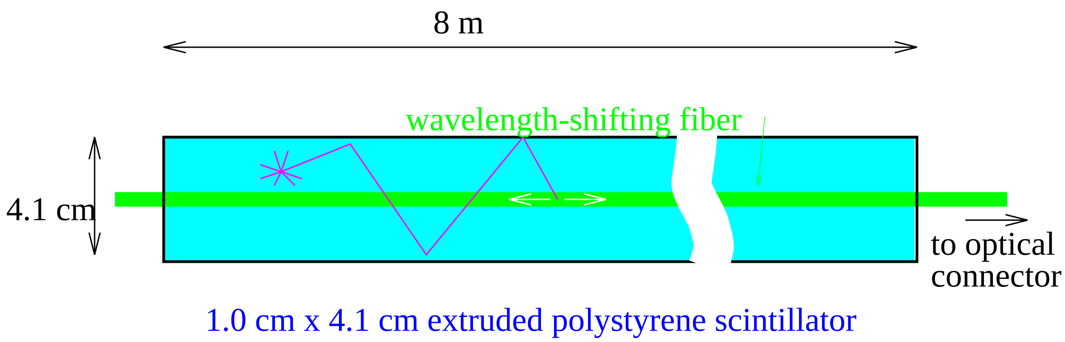


Figure 3. Sketch of a single MINOS plastic scintillator strip. Light produced by passage of charged particles is multiply reflected inside the strip by an outer reflective coating, and eventually may be absorbed inside the 1.2 mm diameter WLS (wavelength shifting) fiber. The fiber re-emits the light isotropically. Some of the light is captured within the fiber and transmitted, via optical connectors and clear fiber ribbon cable, to photodetectors at the both ends of each fiber.

Figure 4. Photograph of Argonne's Ken Wood applying glue to the top surface of a MINOS scintillator module assembly in Building 366, just before the top aluminum cover is installed. The white area in the foreground is the cover of an end manifold, containing the WLS fibers and optical connector. After the aluminum cover is installed, a Mylar sheet is placed over the module and the volume around the module is evacuated to compress and flatten the laminated structure while the glue cures. The pattern of glue lines spaced at 3-inch intervals, shown here, produces an extremely rugged structure, which is easy to handle, ship and install.

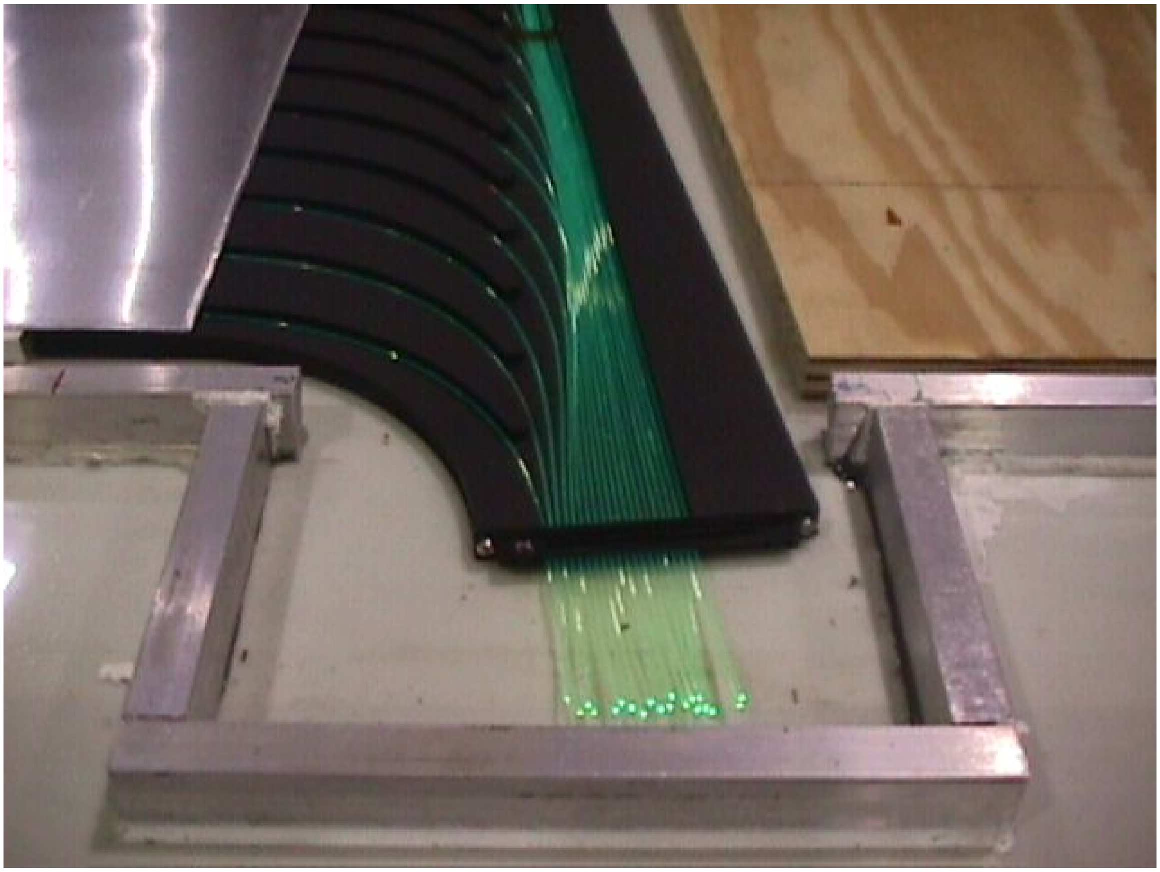


Figure 5. Close-up photograph of a MINOS module end manifold, with the cover removed, showing the 20 WLS fibers routed from the ends of scintillator strips through an optical connector (in the foreground). Each module has a manifold at each end so that scintillation light can be collected from both ends of every WLS fiber. The aluminum bars surrounding the assembly are part of the vacuum enclosure used to flatten and compress the module while the laminating glue cures. The lengths of WLS fibers, which extend beyond the end of the optical connector are cut off and polished after the laminating process is complete.

I.C.6 Electronics Support Group

CDF. We continue with our work in the development of front end electronics for the Shower Max Detector of the CDF Upgrade at Fermilab. For this project, we have overall responsibility for the electronics engineering of the system. The major responsibility in this project involves the coordination of the design engineering and system integration for the entire system, including the development of a custom integrated circuit for the front end electronics, all of the front end boards and crates, and the read-out board which interface to the upper levels of the data acquisition system. The development group has five engineers, seven physicists, one programmer, and four technicians, and is a collaboration between Argonne and Fermilab.

Besides oversight, we are directly responsible for the specification and testing of the custom integrated circuit for the front end electronics, called the SMQIE. In this last period, we completed the evaluation of a design pass of a chip containing pieces of the final circuitry. We worked with Fermilab engineers to specify the final configuration of the chip. A prototype of the final version was submitted in late spring, 1998. Delivery of fabricated chips is expected in fall, 1998.

Argonne is also responsible for the design, testing, and production of the daughter boards which contain the SMQIEs, called SQUIDs. Each SQUID contains two SMQIEs, and also other support circuitry for calibration. We are presently designing the first prototype, which will accommodate the SMQIE now being fabricated. The first board will have the bare die wirebonded directly onto it, since we cannot obtain packaged parts for small quantities of prototype chips. We expect testing to begin in fall, 1998.

Another project that Argonne has direct design responsibility for is the design and production of a VME-based readout board, called the SMXR. This is a sophisticated data processor, which receives digitized data in floating-point form from the front end electronics at the rate of 300 MByte/Sec, adds together up to four words as sampled in time to reconstruct long signals from the detector spread out in time, and also forms trigger bits from the reconstructed signal. The data is stored in a buffer pending read-out by the data acquisition system. We presently have completed the design of the first prototype, and are in the process of doing small system tests. We anticipate that there will be one more design pass by late, 1998, and expect to begin production of ~100 SMXR boards by summer, 1999.

In addition to the Shower Max electronics, we are also involved with two other projects for the CDF Upgrade. One project, called the Isolation Trigger, or ISOPICK, receives information from what is called the Cluster Finder, which identifies a group of hit channels in a detector region that might contain an “interesting” event. The isolation trigger performs algorithms on channels around this “cluster” to look for events arising from isolated photons. The ISOPICK sends the result of the algorithms to the second level trigger, as part of the Level 2 Trigger decision. In the first part of 1998, we completed a design pass of the first ISOPICK prototype. Testing will begin soon, in collaboration with colleagues from Michigan.

The second project is an interface between the Shower Max system and the second level trigger, and is called RECES. This board also receives cluster information, and looks for events which have a signal pointing from the Tracking Detector into the Central Shower Max Detector. This is used to differentiate events containing electrons from other background events, such as hadronic showers or events with pions, and will help reduce triggers from background events. Design of the first prototype of this board is currently in progress.

<u>ATLAS.</u> We have major responsibilities in the development of electronics for the Level 2 Trigger of the ATLAS Detector at CERN. Working with colleagues from Michigan State University, we are responsible for the development of the Level 2 Trigger Supervisor, and the Region of Interest (ROI) Builder. The system assembles data from the first level trigger describing where data from an "interesting event" can be found, requests buffers to pass the data to available Level 2 processors, and communicates to the buffer when to pass the data to the event builder if the event is selected.

In 1997, the Level 2 Trigger Project completed what was called the Demonstrator Program, which was a study of three different system architectures. The architectures differed in how information was transferred to and from the Level 2 system, and how data was processed within the system. Argonne provided both hardware and software support for all three systems. In November, 1997, one of the architectures was chosen as the final configuration.

Following this decision, a new program called the Pilot Project, was organized as the next step in the development of the system. It is designed to use a larger network, and also implement the ROI Builder, the interface from the first level trigger. The function of the ROI Builder is to receive a list of addresses from the Level 1 Trigger identifying where the event data from the "Region of Interest," can be found, collect the addresses on an event by event basis to "build" the event, and make the result available to the Trigger Supervisor for distribution to Level 2 processor.

In spring, 1998, we began designing the first prototype of the ROI Builder. We expect to have hardware available for testing by the latter part of 1998. As part of this effort, we will first build a small system here in the United States, and later transport the system to Saclay, to merge with their system and create a larger network. By the summer of 1999, the system will move to CERN for further testing. It is anticipated that the result of this phase of development will lead to a full specification of the architecture of the Level 2 Trigger System, including the Supervisor and the ROI Builder. We expect that ANL and MSU will have joint responsibility in building these pieces of hardware for the final system.

MINOS. In this last period, we continued our involvement with MINOS, the Neutrino Oscillation Experiment at the Soudan mine. At the close of 1997, the collaboration made several crucial technology decisions, including the choice of solid scintillator for the detector. Most of the work since then was focused on preparing for the Lehman Review, which establishes a baseline design and cost for the project. In this effort, we assisted in reviewing designs, costs, and schedules for the development of the read-out electronics.

One of the remaining technology issues in the project is the choice of the photodetector. The collaboration decided to choose Hamamatsu 16 channel multi-anode phototubes as the baseline design, which allows the plans for the electronics to move forward in developing a Technical Design Report (TDR) for the review. However, a competing proposal is to use or Hybrid Photodiodes (HPDs), which have several desirable properties including better uniformity and higher efficiency. The primary drawbacks with HPDs are uncertainty in their long-term performance, and that they must be read out by a custom integrated circuit which presently does not exist. Clearly, this decision has a great impact on the design of the electronics. Because of these unknowns, it was decided to state in the TDR that the use of HPDs is an alternate proposal. It is planned to make the final technology choice by early 1999.

Presently, the role of Argonne in the development of electronics for the experiment is still under discussion. In the current plan, the United Kingdom has proposed contributing almost all of the engineering and funding for the electronics. We are continuing our discussions with the collaboration, with the goal of obtaining a role in the development effort. We anticipate a decision by the time of the review in the latter part of this year.

ZEUS. The ZEUS experiment at DESY has been running for several years, and is now planning an upgrade to their experiment. One of the projects associated with the upgrade is the replacement of the tracking detector in the forward region. The new tracker will use straw tubes, rather than the older-style wire chamber technology. We anticipate involvement in building front end electronics for this new detector. The system will use a custom integrated circuit developed at PENN. The chip produces discriminated outputs, which are used to measure the time of an event. The project involves building electronics which will interface to the detector, process the discriminated outputs, and transfer them into the existing data acquisition system. The project is presently in the planning stage, but the goal is to develop prototype front end electronics by early 1999, to test with the prototype detector in a test beam at DESY.

II. THEORETICAL PHYSICS PROGRAM

II.A THEORY

II.A.1 Massive Lepton-Pair Production and the Gluon Density

Edmond Berger, Michael Klasen, and Lionel Gordon (Hampton University) proposed and developed a novel idea to extract valuable information on the gluon parton density from data on lepton-pair production in hadron reactions at large transverse momentum, but relatively small values of mass, of the pair. Their paper, Argonne report ANL-HEP-PR-98-27, was published recently in Phys. Rev. **D58**, 074012 (1998). The basic idea is a simple one, but it has been heretofore overlooked. The cross section for massive lepton-pair production (the Drell-Yan process), when integrated over the transverse momentum of the pair, is dominated by quark-antiquark annihilation at large values of the pair mass, and the data are used routinely to extract information on the antiquark parton density. Inclusive prompt photon production at large transverse momentum is dominated by the QCD Compton subprocess, in which an incident gluon and an incident quark react to produce a prompt photon and recoil quark, plus possibly other partons. Data on prompt photon production at large transverse momentum are used regularly to extract the gluon density. The next-to-leading order theoretical analysis of lepton-pair production at large values of the transverse momentum of the pair shows that the set of contributing subprocesses mimic those for prompt photon production. Berger, Gordon, and Klasen demonstrate that the QCD Compton process leading to a virtual photon also dominates the dynamics of lepton-pair production so long as the pair transverse momentum is greater than about half the mass of the pair. Theirs is the first paper to recognize that lepton-pair data should be an excellent new source of information on the gluon density at both fixed-target and collider energies. They also point out advantages of low mass lepton-pair production *vis-à-vis* real hard photon production. There is no non-perturbative fragmentation contribution in lepton pair production so the interpretation is cleaner. In addition, there is no need to isolate the lepton-pair so that theoretical infrared uncertainties associated with isolation are eliminated. There is a wealth of Drell-Yan data in the CDF data sample and at fixed-target energies that can be exploited to advantage to determine useful information on the gluon density.

Berger was invited to speak about their work in a seminar in the Physics Division at Argonne, and Klasen presented the work in theory seminars at the University of Illinois, Urbana, and at the University of Michigan, Ann Arbor.

(E. L. Berger and M. Klasen)

II.A.2 Prompt Photon plus Associated Heavy Flavor Production at Next-to-Leading Order in QCD – Spin Dependence

Edmond Berger and Lionel Gordon continued their investigations of the production of a prompt photon in association with charm, $p + \overline{p} \rightarrow \gamma + c + X$. Their new work concerns the spin dependence of this process, the results of which may be found in Argonne report ANL-HEP-PR-98-39, June, 1998 (hep-ph/9806265), accepted for publication in Physical Review **D** (1998). The analysis is done at next-to-leading order in perturbative QCD. They use a combination of analytic and Monte Carlo integration methods in order to obtain differential distributions, including photon isolation restrictions, that should facilitate contact with experimental results at hadron collider energies. They show that the study of the two-particle inclusive distribution, with specification of the momentum variables of both the final prompt photon and the final heavy quark, tests correlations inherent in the QCD matrix elements. In spin-averaged reactions, the process provides a means for measuring the charm quark density in the nucleon, and when the protons are polarized, the reaction can be used to determine the spin-dependence of the charm quark density. Longer-range plans include performing a next-to-leading order calculation appropriate for HERA experiments, with the prospect of extracting the charm content of the photon.

(E. L. Berger)

II.A.3 Relativistic Corrections to S-Wave Quarkonium Decays

G. Bodwin and A. Petrelli are computing higher-order relativistic corrections to the rates for decays of S-wave heavy-quarkonium states into light hadrons. Specifically, they are computing the short distance coefficients for the relative-order-v^4 corrections to the decays, where v is the heavy-quark-antiquark relative velocity. The relative-order-α_s corrections and the relative-order-v^2 corrections are already known. Thus, the new calculation of Bodwin and Petrelli is the next step in improving the precision of the theory of S-wave decays. In addition, it will provide information about the convergence of the v expansion, which contains some large coefficients in relative-order v^2.

The computation makes use of the covariant-projector method to construct the decay amplitudes of the various spin states and introduces compact expressions for the projectors that are accurate to all orders in v. To date, the computations of short-distance coefficients for the $^3S_1$ decay to light quarks and the $^1S_0$ decay to two gluons have been completed. The computation of the short-distance coefficient for the $^3S_1$ decay to three gluons is more difficult; a preliminary result has been obtained and is now being checked.

The order-v^4 corrections involve three additional color-singlet quarkonium matrix elements for each quarkonium state, beyond those that are required through order v^2. Clearly, it is desirable, in doing phenomenology, to reduce the number of such unknown nonperturbative parameters. Bodwin and Petrelli have shown, by making use of the equations of motion, that one can eliminate one of these matrix elements in favor of the other two. Bodwin and Petrelli have also constructed an all-orders perturbative argument that shows that one of the remaining color-singlet matrix elements, which has a nominal size of order v^4 according to the velocity-scaling rules, is actually of order v^5. The remaining order-v^4 color-singlet matrix element can be expressed in terms of the known order-v^2 matrix element by making use of the vacuum-saturation approximation. There is also a new P-wave color-octet matrix element that contributes in relative order v^4/α_s in the $^3S_1$ decay to three gluons, where it plays a role in canceling an infrared divergence that appears in the relative-order-v^4 color-singlet contribution.

(G. T. Bodwin and A. Petrelli)

II.A.4 Renormalon Ambiguities in Heavy-Quarkonium Decays

This research is described in the report covering the period July 1, 1997—December 31, 1997. During the current reporting period, a paper describing this work (ANL-HEP-PR-98-29) was written and submitted to Physical Review D.

(G. T. Bodwin)

II.A.5 NLO QCD Corrections for SUSY Particle, Photon, and Jet Production

The current focus of my research is the search for supersymmetry (SUSY) at hadron colliders. I am particularly interested in the corrections to the production cross-sections of SUSY particles in hadron collisions in next-to-leading order (NLO) of quantum chromodynamics (QCD). These corrections are in general large and positive. They shift the mass dependence of the cross-sections considerably and can therefore be decisive for the discovery of supersymmetry at the Tevatron or LHC. I calculated the next-to-leading order QCD corrections for charginos, neutralinos and sleptons including massive one-loop contributions and real emission contributions. The dependence of the cross-section on the renormalization and factorization scales was found to be substantially reduced at NLO yielding much more reliable predictions (work in progress).

I am also interested in high energy collisions that involve photons as well as hadrons. These processes are a good source of information on the parton densities in the proton, in particular that of the gluon, and in the photon. Prompt photon production is traditionally used to extract the gluon density of the proton. However, its use is limited by uncertainties from fragmentation contributions and from the necessity to isolate the photon. Both problems are absent if one uses a slightly off-shell photon with large transverse energy that decays into a lepton pair. Theoretically, the real and virtual photon cross-sections are closely related even at next-to-leading order of QCD (ANL-HEP-PR-98-27, hep-ph/9803387, Phys. Rev. D, submitted). For the photoproduction of three jets at HERA I calculated theoretical predictions for generic multijet observables and found good agreement with three-jet data from the ZEUS experiment (ANL-HEP-PR-98-91). However, the complexity of the process restricts this calculation to leading order. This leads to sizable scale uncertainties.

(M. Klasen)

II.A.6 Solving QCD Via Multi-Regge Theory

In invited talks presented at the Workshop on Diffractive Physics, Rio de Janeiro, Brazil (hep-ph/9804207), the 3rd Workshop on Continuous Advances in QCD, Minneapolis (hep-ph/9806474), the 4th Workshop on Quantum Chromodynamics, Paris, France (hep-ph/9810264), and the 5th Low x Physics at HERA, Alan White reported on the contents of his recent Physical Review paper [Phys. Rev. **D58**, 074008 (1998)] and subsequent developments.

Deep-inelastic diffractive scaling violations observed at HERA have provided fundamental insight into the QCD pomeron, suggesting a single gluon inner structure rather than that of a perturbative two-gluon bound state. In White’s work a high-energy, transverse momentum cut-off, confining solution of QCD is obtained. The pomeron, in first approximation, is a single reggeized gluon plus a “wee parton” component that compensates for the color and particle properties of the gluon. This solution corresponds to a supercritical phase of Regge on Field Theory. At small momentum transfer the pomeron is (approximately) a Regge pole, while at larger Q^2, it appears as a single gluon– as suggested by the HERA data. These non-perturbative properties of the pomeron are closely related to the well-known non-perturbative physics of confinement and chiral symmetry breaking–which are also an outcome of White's solution (as properties of the spectrum).

(A. R. White)

II.A.7 Time Dependent Wigner Functions, Characteristics, and Field Theory

Based on recent joint work with D. Fairlie (U. of Durham) and T. Curtright (U. of Miami) [Phys. Rev. **D58**, 025002 (1998)], C. Zachos has continued a longer project on Wigner's phase-space distribution function, this time generalizing Quantum Mechanics to scalar Field Theory: Moyal's deformation quantization alternative to the more conventional Hilbert space and path integral quantizations thus extends to the infinite degrees of freedom of field theory. Although the fields are now c-number functions, they nevertheless compose through a fundamental functional, nonlocal, "star-product" introduced, and describe *quantum* field theory, [ANL-HEP-PR-98-132, hep-th/9810164, J. Phys. A, in press].

The construction introduced is based on the authors' derivations of the time-dependence of Wigner functions, which, in special cases such as the harmonic oscillator, evolve essentially classically. (This is in remarkable contrast to the spreading wavepackets of the conventional formulation of quantum mechanics.) These WFs therefore lend themselves to the natural specification of a powerful interaction picture (Dirac time-dependent perturbation theory), which underlies the generalization to scalar fields described. Field-theoretic duality is then accommodated in field phase-space, on the basis of (in general, nonlinear) canonical transformations in that space.

(C. Zachos)

II.B COMPUTATIONAL PHYSICS

The computational physics effort has been devoted to numerical simulations and measurements in lattice field theories, primarily lattice QCD and other field theories which model its behavior. Transcribing a continuum field theory to a finite lattice reduces it to one with a finite number of degrees of freedom which enables direct numerical simulations while providing the required ultraviolet regulator. For QCD, such lattice methods provide the only reliable way of calculating non-perturbative properties of the theory. This enables one to calculate such basic properties of hadrons as their masses and decay rates. In addition it enables on to study the properties of hot and/or dense hadronic/nuclear matter and its transition to a quark-gluon plasma. Such studies are relevant to the physics of the early universe, neutron stars and relativistic heavy ion collisions such as will be observed at RHIC.

We have been using a new method for lattice fermions—domain-wall fermions—to study zero modes of the Dirac operator and the Atiyah-Singer index theorem in high temperature QCD. This method uses 4-dimensional fermions which live on the 4-dimensional boundaries (domain walls) of a 5-dimensional lattice. Its major advantage is that such fermions (formally) have exact chiral flavor symmetry when the 5th dimension has infinite extent. This contrasts with staggered and Wilson fermions where chiral flavor symmetry is explicitly broken and only returns in the continuum limit. What we have found at the highest temperatures to be studied is that the modes of the Dirac operator clearly separate into two classes, near chiral modes which appear to vanish exponentially as the lattice extent in the 5th dimension is increased, and non-chiral modes which appear to approach a finite constant as the extent in the 5th dimension is increased. These modes which vanish as the 5th dimension is increased appear destined to obey the Atiyah-Singer index theorem in the limit of infinite 5th dimension, and the violations of the chiral Ward identities also show evidence that they will vanish in this limit. Hence, at high enough temperatures domain-wall fermions appear to have the correct chiral behavior. What is more important for them to be of practical use for simulations is that a reasonable approximation of chiral symmetry obtains for lattices of extent ~10 lattice units in the 5th dimension. It remains to be seen how useful they will be at lower temperatures.

We are continuing our work studying the thermodynamics of QCD with a chiral 4-fermion interaction allowing us to work at zero quark mass. On lattices with time extent $N_t = 6$ we have determined that the transition with 2 quark flavors is second order and have obtained a preliminary value (~0.3) for the critical exponent β_m, which describes the temperature variation of the chiral condensate. This compares with the ≈0.35 and ≈0.38 for $O(2)$ and $O(4)$ spin theories which are candidates for field theories which are in the same universality class, and almost certainly excludes the mean field value of 0.5. We expect to obtain a more precise value in the near future, and to extract 2 other critical exponents γ_m and δ, thus allowing us to write down the equation of state describing hadronic matter near the chiral transition to a quark-gluon plasma.

Earlier we had performed calculations of the matrix elements for bottomonium (ϒ and friends) decays which describe the S- and P-wave decays in the Bodwin-Braaten-Lepage factorization scheme. In the P-wave decays this includes decays through a quark-gluon intermediate state, which is only present in real QCD and thus can only be calculated using lattice QCD. Our first calculations had used the quenched (valence-quark) approximation, and gave results which were ~40% too low. Our new preliminary results with dynamical *u* and *d* quarks are much better, and suggest that if we had dynamical *u*, *d* and *s* quarks, we would agree (within error bars) with experiment.

The above simulations/calculations are being performed on the CRAY C-90, the CRAY J-90's and the CRAY T3E at NERSC. Small lattice calculations continue to be performed on divisional PC's and workstations.

(D. K. Sinclair and J.-F. Lagaë)

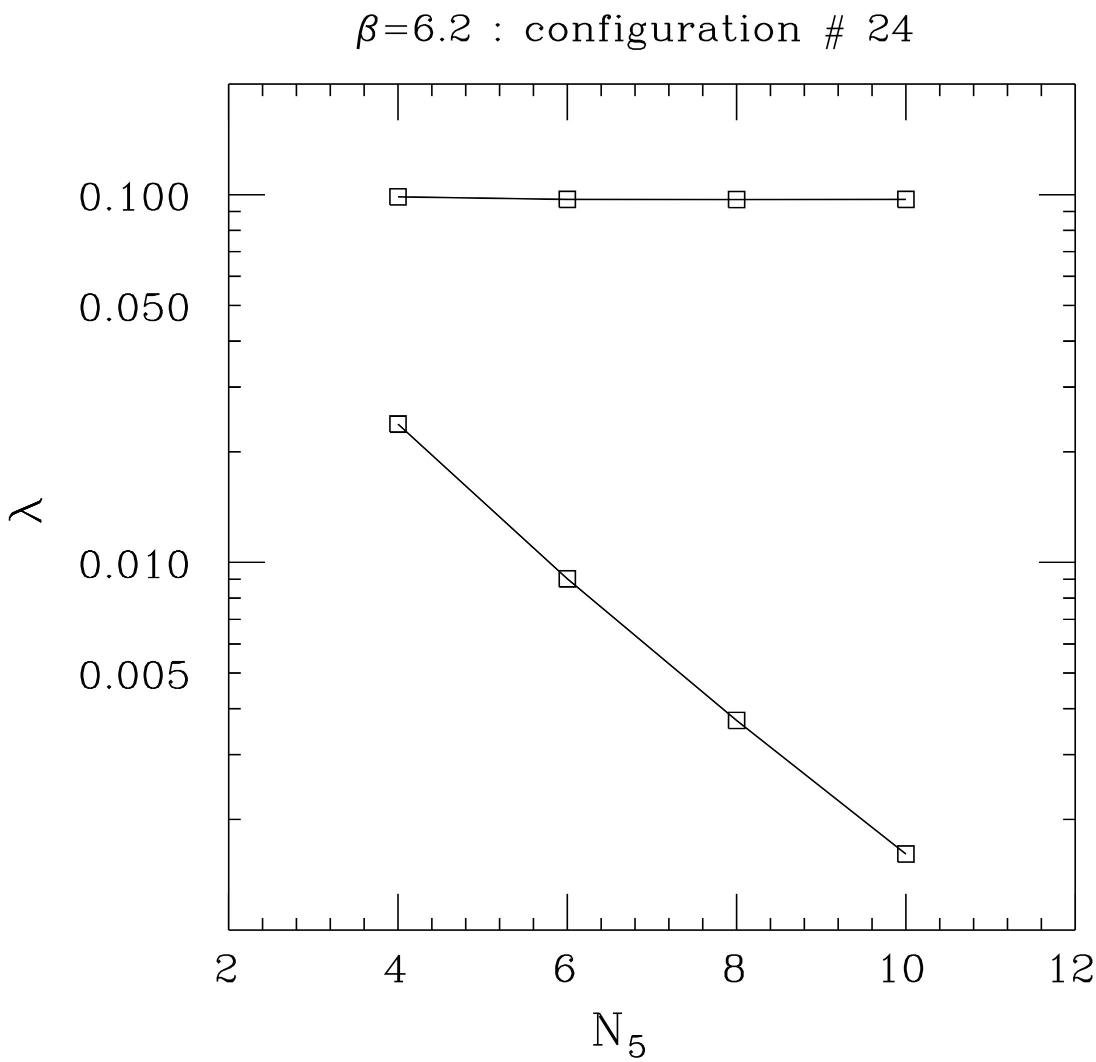


Figure 1. Variation of lowest lying domain-wall Dirac eigen values with lattice extent N_5 in the 5th dimension on a configuration with one instanton.

III. ACCELERATOR RESEARCH AND DEVELOPMENT

III.A ARGONNE WAKEFIELD ACCELERATOR PROGRAM

III.A.1 Multiple Drive Bunch Generation

Multiple drive bunches are essential for generating the long rf pulse necessary for the eventual operation of the Dielectric Wakefield Transformer. We successfully generated such a train of drive bunches in the AWA high current linac by optically splitting and appropriately delaying the laser pulse to the drive gun photocathode. Measurements of rf generation in Stage I of a DWT device were made using a bunch train of 4 bunches of 10 nC each (limited by available laser power), spaced by 3.07 ns corresponding to 4 linac rf periods or 24 wakefield periods. The experiment is described in more detail below in section IV.

III.A.2 SRRC Gun Installation

We have been involved in a collaboration with the Synchrotron Radiation Research Center (Taiwan) to develop an improved high current photoinjector cavity. The design is similar to that of the existing high current gun but incorporates a number of improvements such as better surface preparation to minimize dark current loading and hence increase the available accelerating field at the photocathode. This in turn is expected to allow generation of higher current beams than are presently available at the AWA.

The new gun was fabricated in Taiwan and shipped to Argonne, where it has been installed in the AWA tunnel gun test area. The vacuum and rf hardware have also been installed and the cavity has been tuned using the network analyzer. High power tests are expected to begin in June 1998.

III.A.3 Coherent Cherenkov Radiation Calculations

A technique currently under study for the detection of ultrahigh energy cosmic ray neutrinos involves the measurement of radio emissions from the electromagnetic shower generated by the neutrino in a large volume of naturally occurring dielectric such as the Antarctic ice cap or salt domes. The formation of an electron excess in the shower leads to the emission of coherent Cherenkov radiation, an effect similar to the generation of wakefields in dielectric loaded structures.

Optical Cherenkov radiation from charged particles has been used for many years as a detection technique in elementary particle and cosmic ray physics. The observation that a high energy electromagnetic shower will develop an electron excess due to Compton scattering of atomic electrons by shower photons and annihilation in flight of positrons indicates that coherent Cherenkov radiation will be produced by a shower as well. At very high energies coherent emissions in the radio regime will dominate the incoherent Cherenkov component, making this technique attractive for detection of very high energy cosmic rays. An experiment to measure high energy neutrinos using this effect is currently in progress using the Antarctic icecap as the radiator medium.

There are also some differences between dielectric device wakefields and emissions from showers which will require investigation in dedicated experiments at high energy accelerators. A dielectric wakefield device is a resonant structure due to the presence of the outer conducting boundaries. Thus, the Cherenkov radiation spectrum is discrete, driving only the TM_{0n} modes of the structure (with an axisymmetric beam aligned with the device axis). The beam passes through a vacuum channel rather than directly through the dielectric. Most importantly, there is no development of charge excess, an effect which requires further experimental study using high energy beams.

We have used the finite difference time domain (FDTD) wakefield code ARRAKIS developed by us to model coherent Cherenkov radiation fields from high energy showers. Initial calculations focused on obtaining predictions of expected signals in a proof of principle experiment proposed for the Fermilab Main Injector.

To obtain some idea of the characteristics of the signals, we have developed a slightly simplified model of the planned Fermilab experiment to study the charge excess development via radio emissions in a dielectric target. The shower induced by a single ultrahigh energy cosmic ray will be simulated in the experiment by dumping the proton beam from the Main Injector into an instrumented dielectric radiator. While it would be most desirable to use ice or some other pure dielectric material for the radiator, safety considerations mandate the use of a concrete beam dump for the FNAL experiment. Detailed measurements of the real and imaginary parts of the radiator permittivity will be made prior to the experiment.

The presence of boundaries in the radiator is another potential source of difficulty in relating the laboratory results to the expected behavior of a large volume Antarctic ice-based detector. We plan to use a radio absorbing material on the exterior of the radiator to minimize internal reflections of the Cherenkov signal.

We use an ansatz for the charge excess development which qualitatively reproduces the results of preliminary GEANT simulations. The charge excess is assumed to retain the shape of the initial proton bunch (Gaussian with $\sigma \cong 4$ cm), but with its intensity modulated with a “Landau” envelope, with maximum charge occurring at z= 130 cm.

The radiator is assumed to be surrounded by a layer of rf absorbing material. The absorber conductivity was set to its optimized value, and the electric fields vs. time at a number of probe or antenna points due to coherent Cherenkov radiation from the shower charge excess were calculated. The axial and radial time domain electric fields at these locations approximate the induced electric fields in appropriately polarized pickup antennas placed at those points, although a more realistic calculation would include both the transfer function of the antenna and the spatial variation of the fields across the finite extent of the antenna.

Since the charge excess varies as the shower propagates, the observed signals will vary in intensity depending on the location of the pickup antennas in the radiator. This suggests the possibility of performing a “tomographic” reconstruction of the time evolution of the shower by comparison of observed signals at multiple sample points with the numerical model.

Fourier spectra of the signals show that most of the signal power is contained in the 100-1000 MHz frequency range. The planned sensitivity range of the antennas to be used in the experiment is $\cong$200-500 MHz; this bandwidth is seen to be an adequate match to the signal spectrum.

We have shown how concepts and techniques developed for advanced accelerator R&D can have direct applications to a class of high energy particle detectors. FDTD simulation codes originally designed for accelerator problems will be useful for interpreting results of FNAL and SLAC laboratory measurements of coherent radiation from the charge excess developed in electromagnetic showers.

III.A.4 Dielectric Wakefield Transformer

The dielectric wakefield transformer (DWT) is one route to practical high energy wakefield-based accelerators. Progress has been made in a number of areas relevant to the demonstration of this device; we describe recent bench measurements and beam experiments using 7.8 and 15.6 GHz structures, focusing on recent work involving coupling optimization between the drive and accelerating tubes and with direct measurements of the rf power generated using the intense electron source available at the AWA.

The structures used for these experiments were designed to demonstrate the physics of the DWT while at the same time being compatible with the beam parameters currently available at the AWA. The device parameters are summarized in the Table. Parameters for the dielectric structures: a (b) is the inner (outer) radius, L is the structure length, $c\beta_g$ is the group velocity, and E_z^{max} is the maximum wakefield accelerating gradient.

f (GHz)	Stage	a (mm)	b (mm)	L (mm)	ε	β_g	E_z^{max} (MV/m)
7.8	I	6	11.15	110	4.6	.24	3.2
	II	3	5.41	160	20	.05	8
15.6	I	5	7.22	140	4.6	.31	8
	II	1.5	2.7	140	20	.05	28

The dielectrics used are Cordierite which has ε = 4.6 and MCT20, with ε = 20. Both of these materials are low-loss ceramics which can be easily machined to the dimensions required. Quality factors >5000 have been measured for these structures. With optimized coupling, the 7.8 GHz structure has a transformer ratio of 2.5, while that of the 15.6 GHz device is 3.6.

In the original concept for the DWT, the coupling between structures was accomplished by smoothly deforming the dielectric tubes and coupling the rf through a short unloaded section of waveguide which acted as a quarter wave transformer. This scheme involves no mode conversions and was found to be very efficient based on 2D numerical simulations. The difficulty of deforming the ceramic tubes used as dielectrics led to an alternative method of rf coupling, using a section of rectangular waveguide. A lengthy trial and error procedure of coupling slot adjustments and network analyzer measurements was necessary to obtain reasonable coupling between the structures.

The coupling slot is located about λ_{wake} /4 from the end of the dielectric waveguide and is longer in the azimuthal direction than in the axial. The slot allows the azimuthal magnetic field from the dielectric structure to “leak out” into the rectangular transfer waveguide where it induces a transverse electric field. The coupling slot was gradually widened and lengthened to maximize S_{21} and thus optimize the coupling into the transfer waveguide. The best coupling obtained (from dielectric tube to wave guide) corresponds to $S_{21} \cong$1.1 dB (stage I) and $S_{21} \cong$ 1.8 dB (stage II). Results for the 15.6 GHz device are similar. Work is currently underway to measure the coupling from stage I to stage II for the full transformer assembly.

The stage I dielectric tube and waveguide assembly with the coupling optimized was installed in the test section of the AWA. The rf from the wakefield of the beam in the stage I structure is coupled out through the waveguide to coax adapter to a calibrated rf diode detector via a -60 dB bi-directional coupler. The diode is placed in a lead shielding enclosure to avoid radiation damage to the diode. The diode signal is sent to the control room where it is read out using a digital oscilloscope.

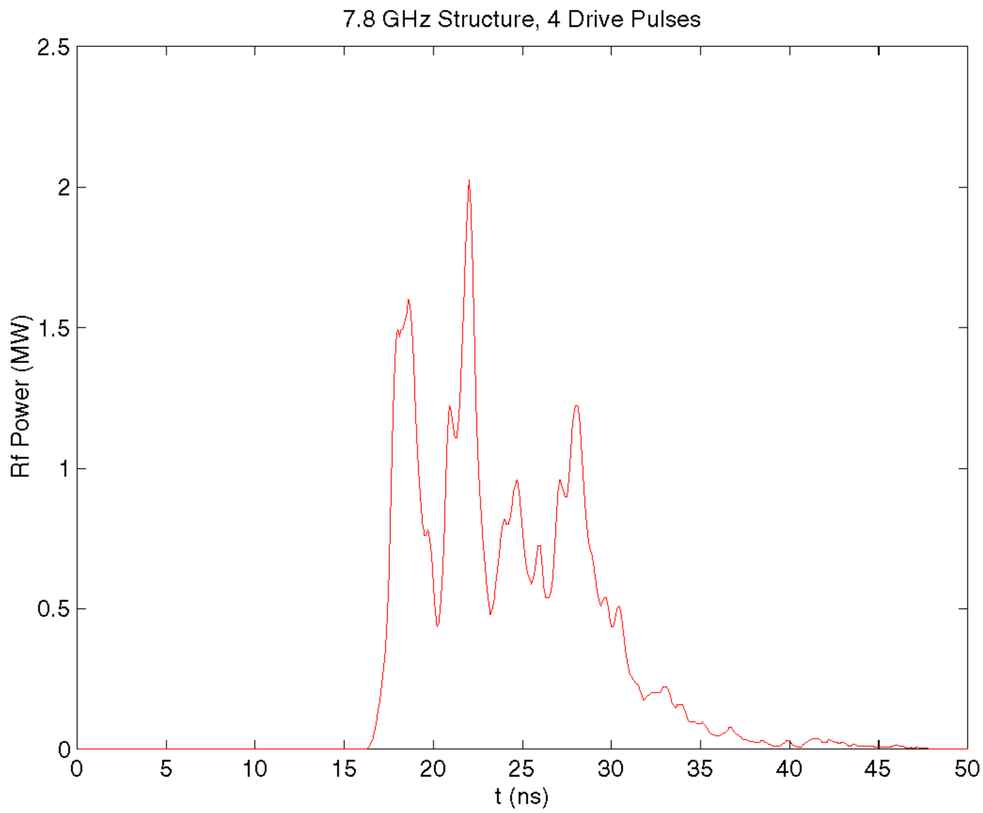


Figure 1. The figure shows the envelope of the rf macropulse generated by the bunch train described in section I for the 7.8 GHz structure. Since the length L of the dielectric structure is 11 cm, the rf micropulse length for a single drive bunch is $(L/c)((1-\beta_g)/\beta_g) \cong 1$ ns which is smaller than the bunch spacing, so that the individual micropulses are visible in the envelope. The difference in amplitudes of the peaks is due to slight misalignments in the beam splitting optics, resulting in different intensities for the micropulses.

Considerable progress has been made towards a demonstration of the dielectric wakefield transformer. Some of the major steps on the way--optimizing the rf coupling from dielectric to transfer structure, multiple drive bunch generation in the AWA linac, and direct measurement of the rf generated by the beam--have been successfully achieved.

(P. V. Schoessow)

III.B MUON COLLIDER R & D

III.B.1 Proton Bunching Experiment at the AGS

During the reporting period of January through June 1998, we did the final data analysis, incorporating a measurement of the signal dispersion and attenuation in the cable from the AGS to the Control Room. The minimum final bunch length obtained was 2 ns, which was distorted by the cable to the 2.2 ns width measured by the digital oscilloscope. A proton bunch of this length would be satisfactory for the muon collider, although it would be desirable to have somewhat shorter bunches. The paper was published in Phys. Rev. Special Topics - Accelerators and Beams in July.

When we were given running time, we were allocated two 24 hour periods, however we lost one of these when the whole laboratory was shut down. There is interest both at Fermilab and Brookhaven in extending our measurements with more precise data of parameters at transition.

III.B.2 Cooling Muons for the Muon Collider

Muon cooling requires that the six dimensional emittance be reduced by a factor of about a million, however cooling is strictly possible only in transverse phase space. In order to cool longitudinal phase space, the emittance must be transferred to the transverse dimensions, where cooling is possible, using emittance exchange sections. Emittance exchange sections use dispersion to expand beams and wedges to rotate phase space in the (p,x) plane. The problem has been that these emittance exchange sections have low admittance and large emittance growth.

The study of bent solenoids using GPT and ICOOL has shown that there are a number of ways of reducing the emittance growth in bent solenoids. Innovations by J. Norem, have led to designs of coupling sections which permitted beams to match the properties of bent solenoids. The simplest of these is a long adiabatic bend which spreads the mismatch over many Larmor periods, however this technique is expensive and would produce excessive decay losses. An improvement of this system, using a coupling section with twice the bend radius and a length of half a Larmor period, couples the beam in the straight directly with the equilibrium position in a bend, in a very short section. This permits the use of bends of arbitrary radius and field giving large dispersion with minimal emittance growth or loss. A further modification of this system by R. Palmer and R. Fernow of BNL, changes the bend radius smoothly with a characteristic length of half a Larmor period. An emittance exchange section designed along these lines is shown in Figure 1. The tight bends produce large dispersion and the total emittance growth is a few per cent.

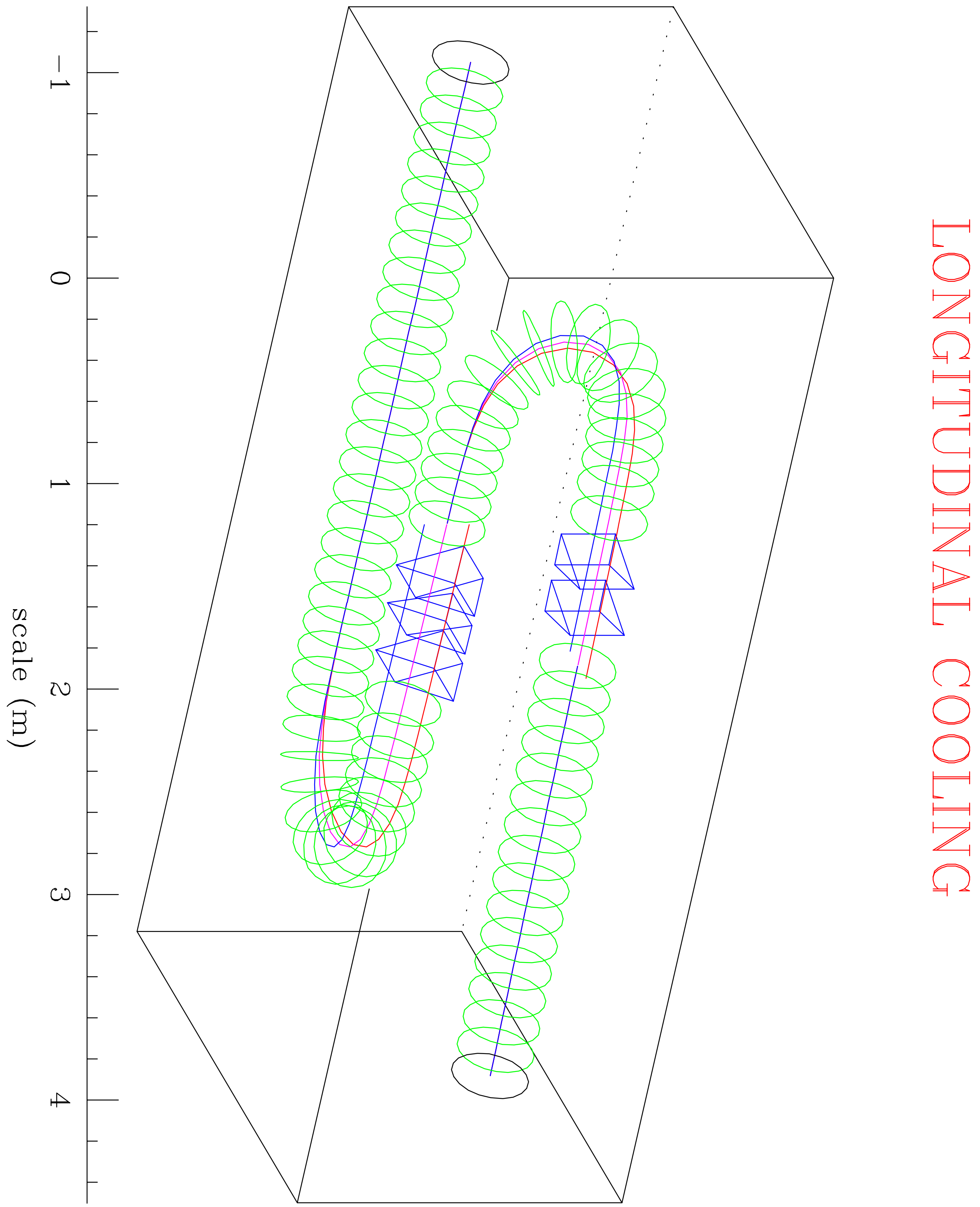


Figure 1. An emittance exchange section using two bends and two wedge sections.

We have also begun to look at the parameters of the Liquid Lithium Lens at the end of the cooling channel. This lens uses large longitudinal currents to create an azimuthal field which focuses the beam. We have begun to develop an overall optimization algorithm for this complex system which would consider beam transport problems, in addition to mechanical problems associated with the lens.

III.B.3 An e/p Collider Ring

A 3 TeV booster with a circumference of 34 km is being considered at Fermilab as part of the VLHC program. An ANL/HEP group is encouraging the VLHC program to consider the possibility of an ep ring in this tunnel. Such a ring would have an e/p center of mass energy of about 1 TeV, and could, perhaps, use very small, simple and low field magnets. If rf was obtainable from CERN, after LEP turned off, an electron ring might be an inexpensive way of insuring new physics from the first stage of the VLHC. A design effort with ANL/ASD and Fermilab is underway.

(J. Norem)

IV. DIVISIONAL COMPUTING ACTIVITIES

IV.A GRAND CHALLENGE APPLICATIONS

IV.A.1 Data Access for High-Energy and Nuclear Physics R&D

Two physicists (L. Price and E. May) and a computer scientist (D. Malon) from DIS division continued to work on the “Grand Challenge Application on HENP Data” project. This is a DOE/ER MICS, HENP-HEP, HENP-NP supported R&D project to provide develop tools to allow High Energy and Nuclear Physicists to analyze and manage the massive amounts of data which will be generated by next generation of experiments. In addition to its direct impact on the success of High Energy and Nuclear Physics experiments this work will also have impact on other governmental and commercial enterprises faced with massive amounts of data. Laboratory and University collaborating partners are LBNL, ANL, BNL, FSU, UCLA, U Tenn., and Yale.

During this interval we worked in the following areas:

1. We attended three collaboration and workshop meetings at FSU, BNL and LBNL. An architectural model for the GCA/HENP data access and storage system was implemented: code for the object oriented data model, object orient database (Objectivity), and “order optimized iterator” components was written, tested and integrated with code produced by other GCA collaborators. Detailed plans and testing procedures were made to participate in the RHIC Mock Data Challenge I at BNL using the GCA/HENP data access and storage system to store and analyze STAR and Phenix simulation data. This will be an important milestone for both the GCA/HENP group and the RHIC computing center.

2. Several visits to CERN were made to work with the RD45 and Atlas Database groups.

3. A paper was written and accepted for presentation at the Computing in High Energy Physics 1998 (CHEP98) conference: “An Architecture for Optimizing Query Processing and Data Delivery in Multilevel Storage Environments.”

4. We provided the core group for the local organizing committee which planned the CHEP’98 conference.

(E. N. May)

V. 1998-1 PUBLICATIONS

V.A JOURNAL PUBLICATIONS, CONFERENCE PROCEEDINGS, BOOKS

"A 3.9 MeV Photoinjector and Delay System for Wakefield Measurements"
J. Power, and M. Conde
Rev. Sci. Inst. 69 (3), 1295 (1998)

"A High Charge and Short Pulse RF Photocathode Gun for Wakefield Acceleration"
W. Gai, X. Li, M. Conde, J. Power, and P. Schoessow
Nucl. Inst. and Meth. in Phys. Research A410, 431 (1998)

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J. Norem (ANL), C. Ankenbrandt, *et al.* (FNAL), L. A. Ahrens, *et al*. (BNAL)
AIP Conference Proceedings 441, "Physics Potential and Development of $\mu^+\mu^-$ Colliders," edited by David B. Cline, (Center for Advanced Accelerators and the Univ. of Calif., Los Angeles, CA, 1997) p. 314.

"An ODMG-Compatible Testbed Architecture for Scalable Management and Analysis of Physics Data"
D. M. Malon, E. N. May
Computer Physics Communications 110, 120 (1998)

"Anomalous $W^+W^- t\bar{t}$ Couplings at the e^+e^- Linear Collider"
F. Larios, T. Tait, and C.-P. Yuan
Phys. Rev. D57, 3106 (1998)

"Angular Dependence of pp Spin Correlation and Rescattering Observables Between 1.80 and 2.10 GeV"
C. E. Allgower, T. E. Kasprzyk, H. M. Spinka, *et al.*
Eur. Phys. J. C1, 131 (1998)

"Bunching Near Transition in the BNL AGS"
J. Norem (ANL), C. Ankenbrandt, *et al.* (FNAL), L. A. Ahrens, *et al.* (BNAL)
Phys. Rev. Special Topics, "Accelerators and Beams," 1, 030101 (1998)

"Critical Database Technologies for High Energy Physics"
D. M. Malon and E. N. May
Proceedings of the 23rd International Conference On Very Large Databases (VLDB '97) (1998) p. 580.

"Deep Inelastic Diffraction and the Pomeron as a Single Gluon"

A. R. White

"Recent Advances in Hadron Physics," Proceedings of the International Conference on Elastic and Diffractive Scattering (VIIth Blois Workshop), edited by K. Kang, *et al.* (World Scientific, Singapore, 1998) pp. 60-68.

"Detectors for the MINOS Long-Baseline Neutrino Oscillation Experiment"

D. S. Ayres

Nuclear Physics 61B (Proc. Suppl.), 12 (1998)

"Detector Limitations, STAR"

D. Underwood

Proceedings of the RIKEN BNL Research Center Workshop, "RHIC Spin Physics," 7, edited by G. Bunce, *et al.*, Upton, NY, 1998) p. 211.

"Diffractive Dijet Cross Sections in Photoproduction at HERA"

J. Breitweg, M. Derrick, D. Krakauer, S. Magill, D. Mikunas, B. Musgrave, J. Repond, R. Stanek, R. L. Talaga, R. Yoshida, H. Zhang (ANL) and the ZEUS Collaboration

Eur. Phys. J. C5, 41 (1998)

"Dijet Cross Sections in Photoproduction at HERA"

J. Breitweg, M. Derrick, D. Krakauer, S. Magill, D. Mikunas, B. Musgrave, J. Repond, R. Stanek, R. L. Talaga, R. Yoshida, H. Zhang (ANL) and the ZEUS Collaboration

Eur. Phys. J. C1, 109 (1998)

"Dijet Production by Color-Singlet Exchange at the Fermilab Tevatron"

R.E. Blair, K.L. Byrum, E. Kovacs, S.E. Kuhlmann, T. LeCompte, L. Nodulman, J. Proudfoot, R. Thurman-Keup, R.G. Wagner, A.B. Wicklund (ANL), and the CDF Collaboration

Phys. Rev. Lett. 80, 1156 (1998)

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J. Norem

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"Effects of QCD Resummation on W^+h and $t\bar{b}$ Production at the Tevatron"

S. Mrenna and C.-P. Yuan

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"EPR in B Physics and Elsewhere"

H. J. Lipkin

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Phys. Rev. Special Topics, "Accelerators and Beams," 1, 041302 (1998)

"Higgs Bosons with Large Bottom Yukawa Coupling at Tevatron and LHC"
J. Lorenzo, Diaz-Cruz, H.-J. Ne, T. Tait, and C. –P. Yuan
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"High-E_T Inclusive Jet Cross Sections in Photoproduction at HERA"
J. Breitweg, M. Derrick, D. Krakauer, S. Magill, D. Mikunas, B. Musgrave, J. Repond, R. Stanek, R. L. Talaga, R. Yoshida, H. Zhang (ANL) and the ZEUS Collaboration
Eur. Phys. J., C2, 237 (1998)

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P. Schoessow, M. E. Conde, W. Gai, R. Konecny, J. Power, and J. Simpson
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J.-F. Lagaë and D. K. Sinclair
Nucl. Phys. (Proc. Suppl.) 63, 892 (1998)

"Inclusive Jet Production in γp and $\gamma\gamma$ Processes: Direct and Resolved Photon Cross Sections in Next-to-Leading Order QCD"
M. Klasen (ANL), T. Kleinwort (DESY) and G. Kramer (Universitat Hamburg)
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E. L. Berger, Xiaofeng Guo, and Jianwei Qiu
Proceedings of the 9th Meeting of the Division of Particles and Fields of the American Physical Society (DPF '96), edited by K. Heller, *et al.* (World Scientific, Singapore, 1998) pp. 452-455.

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L. E. Gordon
Proceedings of the Eleventh International Workshop on Photon-Photon Collisions (PHOTON '97) edited by A. Buijs and F. C. Erne (World Scientific, Singapore, 1998) p. 173.

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R. E. Blair , K. L. Byrum, D. Crane, T. A. Fuess, L. Nodulman, J. Proudfoot, R. G. Wagner, A. B. Wicklund (ANL) and the CDF Collaboration

Phys. Rev. D57, 1359 (1998)

"Luminosity Monitor"

D. Underwood

Proceedings of RIKEN BNL Research Center Workshop, "RHIC Spin Physics," 7 (1998) pp. 189-194.

"Matrix Membranes and Integrability"

C. Zachos, D. Fairlie, and T. Curtright

"Springer Lecture Notes in Physics," V502, edited by H. Aratyn, *et al*., (Springer-Verlag, Heidelberg, 1998) pp. 183-196.

"Measurement of B Hadron Lifetimes Using $\boldsymbol{J/}\psi$ Final States at CDF"

R. E. Blair, K. L. Byrum, S. E. Kuhlmann, L. Nodulman, J. Proudfoot, R. Thurman-Keup, R. G. Wagner, A. B. Wicklund (ANL) and the CDF Collaboration

Phys. Rev. D57, 5382 (1998)

"Measurement of the $B^0-\overline{B}^0$ Oscillation Frequency Using $\pi-B$ Meson Charge-Flavor Correlations in $\boldsymbol{p\bar{p}}$ Collisions at $\sqrt{s}$ = 1.8 TeV"

R. E. Blair, K. L. Byrum, E. Kovacs, S. E. Kuhlmann, T. LeCompte, L. Nodulman, J. Proudfoot, R. Thurman-Keup, R. G. Wagner, A. B. Wicklund (ANL), and the CDF Collaboration

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"Measurement of the Differential Cross Section for Events with Large Total Transverse Energy in $\boldsymbol{p\bar{p}}$ Collisions at $\sqrt{s} = 1.8$ TeV"

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Phys. Rev. Lett. 80, 3461 (1998)

"Measurement of the Diffractive Structure Function $F_2D(4)$ at HERA"

J. Breitweg, M. Derrick, D. Krakauer, S. Magill, D. Mikunas, B. Musgrave, J. Repond, R. Stanek, R. L. Talaga, R. Yoshida, H. Zhang (ANL) and the ZEUS Collaboration

Eur. Phys. J. C1, 81 (1998)

"Measurement of Jet Shapes in Photoproduction at HERA

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"Measurement of Single Spin Asymmetry in η-Meson Production in $p\uparrow p$- and $\bar{p}\uparrow p$-Interactions in the Beam Fragmentation Region at 200 GeV/c"

D. Grosnick, D. Hill, M. Laghai, D. Lopiano, Y. Ohashi, T. Shima, H. Spinka, R. Stanek, D. Underwood, and A. Yokosawa and the FNAL E-704 Collaboration

Nucl. Phys. B510, 3 (1998)

"Measurement of the $t\bar{t}$ Production Cross Section in $p\bar{p}$ Collisions at $\sqrt{s} = 1.8$ TeV"

R. E. Blair, K. L. Byrum, E. Kovacs, S. E. Kuhlmann, T. LeCompte, L. Nodulman, J. Proudfoot, R. Thurman-Keup, R. G. Wagner, A. B. Wicklund (ANL), and the CDF Collaboration

Phys. Rev. Lett. 80, 2773 (1998)

"Measurement of the Top Quark Mass"

R. E. Blair, K. L. Byrum, E. Kovacs, S. E. Kuhlmann, T. LeCompte, L. Nodulman, J. Proudfoot, R. Thurman-Keup, R. G. Wagner, A. B. Wicklund (ANL), and the CDF Collaboration

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"Measurement of the Top Quark Mass and $t\bar{t}$ Production Cross Section from Dilepton Events at the Collider Detector at Fermilab"

R. E. Blair, K. L. Byrum, E. Kovacs, S. E. Kuhlmann, T. LeCompte, L. Nodulman, J. Proudfoot, R. Thurman-Keup, R. G. Wagner, A. B. Wicklund (ANL), and the CDF Collaboration

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"Observation of Hadronic *W* Decays in $t\bar{t}$ Events with the Collider Detector at Fermilab"

R. E. Blair, K. L. Byrum, E. Kovacs, S. E. Kuhlmann, T. LeCompte, L. Nodulman, J. Proudfoot, R. Thurman-Keup, R. G. Wagner , A. B. Wicklund (ANL), and the CDF Collaboration

Phys. Rev. Lett. 80, 5720 (1998)

"Overcoming Intrinsic Spin Resonances with an rf Dipole"

H. M. Spinka, D. G. Underwood, A. Yokosawa, M Bai, and K. Krueger

Phys. Rev. Lett. 80 (21), 4673 (1998)

"Photon Pair Production with Soft Gluon Resummation in Hadronic Interactions"

E. L. Berger, S. Mrenna, C.-P. Yuan, and C. Balazs

Phys. Rev. D57, 6934 (1998)

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"Prompt Photon Plus Jet Photoproduction at HERA at Next-to-Leading Order in QCD"
L. E. Gordon
Phys. Rev. D57, 235 (1998)

"Propagation of Short Electron Pulses in a Plasma Channel"
M. E. Conde and W. Gai (ANL), N. Barov and J. B. Rosenzweig (UCLA)
Phys. Rev. Lett. 80 (1), 81 (1998)

"Properties of Jets in *W* Boson Events from 1.8 TeV $\bar{p}p$ Collisions"
R. E. Blair, K. L. Byrum, R. Thurman-Keup, S. E. Kuhlmann, T. LeCompte, L. Nodulman, J. Proudfoot, R. B. Wagner, A. B. Wicklund (ANL), and the CDF Collaboration
Phys. Rev. Lett. 79, 4760 (1997)

"Properties of Photon Plus Two-jet Events in pp Collisions at $\sqrt{s}$ =1.8 TeV"
L. Nodulman, R. E. Blair, K. L. Byrum, R. Thurman-Keup, T. LeCompte, J. Proudfoot, R. G. Wagner, A. B. Wicklund, and the CDF Collaboration
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"Query Estimation and Order-Optimized Iteration in Very Large Federations"
D. Malon
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"Search for Chargino-Neutralino Associated Production at the Fermilab Tevatron Collider"
R. E. Blair, K. L. Byrum, E. Kovacs, S. E. Kuhlmann, T. LeCompte, L. Nodulman, J. Proudfoot, R. Thurman-Keup, R.G. Wagner, A. B. Wicklund (ANL), and the CDF Collaboration
Phys. Rev. Lett. 80, 5275 (1998)

"Search for the Decays $B_d^0 \to \mu^+\mu^-$ and $B_s^0 \to \mu^+\mu^-$ in $p\bar{p}$ Collisions at $\sqrt{s}$ = 1.8 TeV"
R. E. Blair, K. L. Byrum, S. E. Kuhlmann, T. LeCompte, L. Nodulman, J. Proudfoot, R. Thurman-Keup, R. G. Wagner, A. B. Wicklund, (ANL) and the CDF Collaboration
Phys. Rev. D57, R3811 (1998)

"Search for Flavor-Changing Neutral Current Decays of the Top Quark in $p\bar{p}$ Collisions at $\sqrt{s} = 1.8$ TeV"
R. E. Blair, K. L. Byrum, E. Kovacs, S. E. Kuhlmann, T. LeCompte, L. Nodulman, J. Proudfoot, R. Thurman-Keup, R. G. Wagner, A. B. Wicklund (ANL), and the CDF Collaboration
Phys. Rev. Lett. 80, 2525 (1998)

“Search for the Proton Decay Mode $p \to \nu K^+$ in Soudan 2”

M. C. Goodman, D. S. Ayres, T. H. Fields, T. Joffe-Minor, W. Leeson, L. E. Price, R. Seidlein, J. L. Thron (ANL) and the Soudan 2 Collaboration

Phys. Lett. B<u>427</u>, 217 (1998)

“Searching for Neutrino Oscillations”

M. C. Goodman

SLAC “Beam Line,” <u>28</u> (2C), 9 (1998)

“Spin-Dependent Drell-Yan in QCD to $O(\alpha_s^2)$ (I). (The Non-Singlet Sector)”

L. Gordon (ANL), S. Chang, D. Coriano, and R. D. Field (Univ. of Florida)

Nucl. Phys. B<u>512</u>, 393-428 (1998)

“The Structure of the Bern-Kosower Integrand for the N-Gluon Amplitude”

C. Schubert

Eur. Phys. J. C<u>5</u>, 693 (1998)

“The VIIth BLOIS Workshop: Theory Summary and Factorization Issues”

A.R. White

“Recent Advances in Hadron Physics,” <u>Proceedings of the International Conference on Elastic and Diffractive Scattering</u> (VIIth Blois Workshop), edited by K. Kang, *et al*. (World Scientific, Singapore, 1998) pp. 346-356.

“Thermodynamics of Lattice QCD with Chiral Four Fermion Interactions”

J. B. Kogut, J. F. Lagaë, and D. K. Sinclair

Phys. Rev. D<u>58</u>, 034504 (1998)

“Threshold Resummation of the Total Cross Section for Heavy Quark Production in Hadronic Collisions”

E. L. Berger and H. Contopanagos

Phys. Rev. D<u>57</u>, 253 (1998)

“Topology, Fermionic Zero Modes and Flavor Singlet Correlators in Finite Temperature QCD”

J. B. Kogut, J.-F. Lagaë, and D. Sinclair

Nucl. Phys. (Proc. Suppl.) <u>63</u>, 433 (1998)

“Topology, Fermionic Zero Modes and Flavor Singlet Correlators in Finite Temperature QCD”

J. B. Kogut, J.-F. Lagaë, and D. K. Sinclair

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“Total Cross Section for Top Quark Production”

E. L. Berger and H. Contopanagos

<u>Proceedings of the 9th Meeting of the Division of Particles and Fields of the American Physical Society</u> (DPF ‘96), edited by K. Heller, *et al.* (World Scientific, Singapore, 1998), pp. 656-659.

V.B PAPERS SUBMITTED FOR PUBLICATION

"Bose-Einstein Correlations and Color Reconnection in W-Pair Production"
S. V. Chekanov
Eur. Phys. J. C
ANL-HEP-PR-98-84

"Color-Octet Effects in Radiative Υ Decays"
A. Petrelli (ANL) and F. Maltoni (CERN)
Phys. Rev. D
ANL-HEP-PR-98-44

"Direct Reconstruction of np Elastic Scattering Amplitudes Between 0.80 and 1.1 GeV"
H. Spinka and D. Lopiano (ANL), *et al.*
IL NUOVO CIMENTO
ANL-HEP-PR-98-136

"Exclusive Electroproduction of Rho 0 and J/Psi Mesons at HERA"
J. Breitweg, S. Chekanov, M. Derrick, D. Krakauer, S. Magill, D. Mikunas, B. Musgrave, J. Repond, R. Stanek, R. Talaga, R. Yoshida, H. Zhang (ANL), and the ZEUS Collaboration
Eur. Phys. J.
ANL-HEP-PR-98-95

"Forward Jet Production in Deep Inelastic Scattering at HERA"
J. Breitweg, M. Derrick, D. Krakauer, S. Magill, D. Mikunas, B. Musgrave, J. Repond, R. Stanek, R. L. Talaga, R. Yoshida, H. Zhang (ANL) and the ZEUS Collaboration
Eur. Phys. J. B
ANL-HEP-PR-98-50

"Higgs Bosons with Large Bottom Yukawa Coupling at Tevatron and LHC"
J. Lorenzo Diaz-Cruz, H.-J. He., T. Tait, and C.-P. Yuan
Phys Rev. Lett.
ANL-HEP-PR-98-10

"Improved Staggered Quark Actions with Reduced Flavour Symmetry Violations for Lattice QCD"
J.-F. Lagaë and D. K. Sinclair
Phys. Rev. D
ANL-HEP-PR-98-51

“Large Analyzing Power in Inclusive Pi +/- Production at High x_F with a 22-GeV/c Polarized Proton Beam”

C. Allgower, K. Krueger, T. Kasprzyk, H. Spinka, D. Underwood, and A. Yokosawa (ANL), *et al.*

Phys. Rev. Lett.

ANL-HEP-PR-98-127

“Long-Range Correlations in Deep Inelastic Scattering”

S. V. Chekanov

Eur. Phys. J.

ANL-HEP-PR-98-46

“Massive Lepton Pairs as a Prompt Photon Surrogate

E. L. Berger, L. E. Gordon, and M. Klasen

Phys. Rev. D

ANL-HEP-PR-98-27

“Measurement of Elastic Upsilon Photoproduction at HERA”

J. Breitweg, M. Derrick, D. Krakauer, S. Magill, D. Mikunas, B. Musgrave, J. Repond, R. Stanek, R. Talaga, R. Yoshida, H. Zhang (ANL), and the ZEUS Collaboration

Eur. Phys. J.

ANL-HEP-PR-98-96

“Measurement of Inclusive D*+ and Associated Dijet Cross Sections in Photoproduction at HERA”

J. Breitweg, M. Derrick, D. Krakauer, S. Magill, D. Mikunas, B. Musgrave, J. Repond, R. Stanek, R. Talaga, R. Yoshida, H. Zhang (ANL), and the ZEUS Collaboration

Eur. Phys. J.

ANL-HEP-PR-98-97

“Measurement of Jet Shapes in High-Q2 Deep Inelastic Scattering at HERA”

J. Breitweg, M. Derrick, D. Krakauer, S. Magill, D. Mikunas, B. Musgrave, J. Repond, R. Stanek, R. Talaga, R. Yoshida, H. Zhang (ANL), and the ZEUS Collaboration

Eur. Phys. J.

ANL-HEP-PR-98-37

“Measurement of the Diffractive Cross Section in Deep Inelastic Scattering Using ZEUS 1994 Data”

J. Breitweg, M. Derrick, D. Krakauer, S. Magill, D. Mikunas, B. Musgrave, J. Repond, R. Stanek, R. Talaga, R. Yoshida, H. Zhang (ANL), and the ZEUS Collaboration

Eur. Phys. J.

ANL-HEP-PR-98-98

“Scale Dependence of Squark- and Gluino-Production Cross Sections”

E. L. Berger, M. Klasen, and T. Tait

Phys. Rev. D

ANL-HEP-PR-98-48

“Scale Invariant Dynamical Fluctuations in Jet Physics”
S. V. Chekanov
Eur. Phys. J. C
ANL-HEP-PR-98-21

“Study of the Uncertainty of the Gluon Distribution”
S. Kuhlmann
Accepted for publication Phys. Rev. D
ANL-HEP-PR-98-09

“The *pp* Elastic Scattering Analyzing Power Measured with the Polarized Beam and the Unpolarized Target Between 1.98 and 2.80 GeV”
C. E. Allgower, M. Beddo, D. Grosnick, T. E. Kasprzyk, D. Lopiano, H. M. Spinka (ANL), *et al.*
Nucl. Phys. A
ANL-HEP-PR-98-128

“Wakefield Excitation in Multimode Structures by a Train of Electron Bunches”
Wei Gai, J. Power, and P. Schoessow
Phys. Rev. E
ANL-HEP-PR-98-115

“x-Dependent Polarized Parton Distributions”
L. E. Gordon, G. P. Ramsey (ANL) and M. Goshtasbpour (Shahid Beheshti University and the Center for Theoretical Physics and Mathematics)
Accepted for publication in Phys. Rev. D
ANL-HEP-PR-98-08

“ZEUS Results on the Measurement and Phenomenology of F2 at Low x and Low Q2”
J. Breitweg, S. Chekanov, M. Derrick, D. Krakauer, S. Magill, D. Mikunas, B. Musgrave, J. Repond, R. Stanek, R. L. Talaga, R. Yoshida, H. Zhang, and the ZEUS Collaboration
Eur. Phys. J.
ANL-HEP-PR-98-120

V.C PAPERS OR ABSTRACTS SUBMITTED TO CONFERENCES

"A $\sqrt{S} = 1$ TeV *ep* Collider at Fermilab"
D. Krakauer, J. Repond, and J. Norem
Presented at the Workshop on Deep Inelastic Scattering, Brussels, Belgium, April 5-8, 1998
ANL-HEP-CP-98-133

"Coherent Multimoded Dielectric Wakefield Accelerators"
J. Power, W. Gai, and P. Schoessow
Presented at the 8th Workshop on Advanced Accelerator Concepts (AAC '98), Baltimore, MD, July 5-11, 1998, Dr. Wes Lawson, editor
ANL-HEP-CP-98-87

"Design of a High Charge (10 - 100 nC) and Short Pulse (2 - 5 ps) RF Photocathode Gun for Wakefield Acceleration"
W. Gai, M. Conde, J. Power, P. Schoessow, and X. Li (Visiting Scholar)
Presented at the 8th Workshop on Advanced Accelerator Concepts (AAC '98), Baltimore, MD, July 5-11, 1998, Dr. Wes Lawson, editor
ANL-HEP-CP-98-85

"High Charge Short Electron Bunches for Wakefield Accelerator Structures Development"
M. E. Conde, W. Gai, R. Konecny, J. G. Power, P. Schoessow
Presented at the XIX International LINAC Conference (LINAC '98), Chicago, IL, August 24-28, 1998
ANL-HEP-CP-98-100

"High Power Test Results of the First SRRC/ANL High Current L-Band RF Gun"
M. Conde, W. Gai, R. Konecny, J. Power, and P. Schoessow (ANL), C. H. Ho, *et al.*
Presented at the XIX International LINAC Conference (LINAC '98), Chicago, IL, August 23-28, 1998
ANL-HEP-CP-98-94

"Large NMR Signals and Polarization Asymmetries"
T. E. Kasprzyk, H. M. Spinka (ANL), *et al.*
Presented at the Workshop on NMR in Polarized Targets, Charlottesville, NC, April, 1998
ANL-HEP-CP-98-135
LA-UR-98-4575

"Measurement of the CP Asymmetry Parameter Sin(2B) at CDF"
T. J. LeCompte, for the CDF Collaboration
Presented at the Violation Center for the Subatomic Structure of Matter Conference, Adelaide, Australia, July 3-8, 1998
ANL-HEP-CP-98-102

"Modeling Coherent Cherenkov Radio Emissions From High Energy Electromagnetic Showers"
P. Schoessow and Wei Gai
Accepted for publication in the Proceedings of the Quantum Aspects of Beam Physics Conference (QABP '98), Monterey, CA, January 4-9, 1998
ANL-HEP-CP-98-35

"Physics with the STAR Detector at RHIC"
T. LeCompte
Presented at the Workshop on Particle Distributions in Hadronic and Nuclear Collisions, U. of I. at Chicago, Chicago, IL, June 11-13, 1998
ANL-HEP-CP-98-90

"Quarkonium Physics at STAR"
T. J. LeCompte, for the STAR Collaboration
Presented at the Workshop on Quarkonium Production in Relativistic Nuclear Collisions, Institute for Nuclear Theory, Seattle, WA, May 11-15, 1998
ANL-HEP-CP-98-131

"Resonant Excitation of Plasma Wakefields using Multiple Electron Bunches"
M. E. Conde and W. Gai
Presented at the 8th Workshop on Advanced Accelerator Concepts (AAC '98), Baltimore, MD, July 6-11, 1998
ANL-HEP-CP-98-99

"RF Power Generation and Coupling Measurements for the Dielectric Wakefield Step-Up Transformer"
M. E. Conde, W. Gai, R. Konecny, J. Power, P. Schoessow, and P. Zou
Presented at the 8th Workshop on Advanced Accelerator Concepts (AAC '98), Baltimore, MD, July 5-11, 1998
ANL-HEP-CP-98-86

"Solving QCD Using Multi-Regge Theory"
A. R. White
Presented at the Third Workshop on Continuous Advances in QCD, Minneapolis, MN, April 16-19, 1998
ANL-HEP-CP-98-67

"Solving QCD Using Multi-Regge Theory"
A. R. White
Presented at the 4th Workshop on Quantum Chromodynamics, Paris, France, June 1-6, 1998
ANL-HEP-CP-98-130

"SRRC/ANL High Current L-Band Single Cell Photocathode RF Gun"
W. Gai, M. Conde, R. Konecny, J. Power, P. Schoessow (ANL),
and C.H. Ho, *et al*. (Synchrotron Radiation Research Center)
Presented at the 6th European Particle Accelerator Conference (EPAC '98), Stockholm City Conference Center, June 22-26, 1998, Stockholm, SWEDEN
ANL-HEP-CP-98-60

"The Measurement of the Mass of the W Boson from the Tevatron"
R. Thurman Keup
Presented at the 2nd Latin American Symposium on High Energy Physics, San Juan, Puerto Rico, April 8-11, 1998
ANL-HEP-CP-98-89

"The Supercritical Pomeron in QCD"
A. R. White
Invited talk presented at the LAFEX International Workshop on Diffractive Physics, Rio de Janeiro, Brazil, February 16-20, 1998
ANL-HEP-CP-98-31

"Thermodynamics of Lattice QCD with 2 Quark Flavours: Chiral Symmetry and Topology"
J.-F. Lagaë, D.K. Sinclair, and J. Kogut
Presented at the Workshop on Nonperturbative Methods in Quantum Field Theory, Adelaide, South Australia, Feb. 2-13, 1998
ANL-HEP-CP-98-49

V.D TECHNICAL REPORTS AND NOTES

"Conceptual Design of the Inner Cryostat Support and Jack"
V. Guarino and E. Petereit
ANL-HEP-TR-98-04

"Investigation of the Timesaver Process for De-Burring and Cleaning the Plate for the ATLAS TileCalorimeter"
V. Guarino, L. Kocenko, and K. Wood
ANL-HEP-TR-98-05

"Quality Assurance Plan for Atlas Raw Steel Sheets"
V. J. Guarino
ANL-HEP-TR-98-11

"Steel Specification for the Atlas Calorimeter"
V. J. Guarino
ANL-HEP-TR-98-12

"Stress Analysis of the Welds in the Girder"
V. J. Guarino
ANL-HEP-TR-98-06

CDF Notes:

CDF-4465 "Study of the Uncertainty of the Gluon Distribution"
J. Huston and S. Kuhlmann

CDF-4534 "Improved Measurement of the B^- and $\overline{B}^\circ$ Meson Lifetimes Using Semileptonic Decays"
F. Ukegawa, A. B. Wicklund, and N. Lockyer
(submitted to Phys. Rev. D)

CDF-4535 "A Prototype Calibration Database for Run 2"
P. Mazzanti, J. Proudfoot, and F. Semeria

CDF-4568 "Criteria for Data Handling: CDF Physics Groups"
Henry Frisch, Jodi Lamoreux, Mark Lancaster, Jonathan Lewis, Simona Rolli, David Stuart, Slawek Tkaczyk, Kirsten Tollefson, A. Barry Wicklund, and Weiming Yao

CDF-4616 "Update on the B^- and $\overline{B}^\circ$ = Lifetime Measurement Using Semileptonic Decays"
F. Ukegawa and A. B. Wicklund

CDF-4620 "Particle Level Study of $H \rightarrow \overline{b}b$"
A. Bocci, D.Costanzo, S. Kuhlmann, S. Lami, G. Latino, and R. Paoletti

CDF-4651 "Error on sin(2β) in Run II"
P. Maksimovic and A. B.Wicklund

PDK Notes:

PDK 694 "Notes about the October 29, 1997 Video Conference on Blasting"
T. Fields

PDK 697 "Pre-MINOS Test Blast Vibration Studies at the Soudan 2 Site"
V. J. Guarino and D. J. Jankowski

PDK 698 “Search for the Proton Decay Mode $p \to \nu K^{+}$ in Soudan 2”
D. S. Ayres, T. H. Fields, M. C. Goodman, T. Joffe-Minor, W. Leeson,
L. E. Price, R. Seidlein, J. L. Thron (ANL), and the Soudan 2 Collaboration
Published in Phys. Lett. B427, 217-224 (5/14/98)

PDK 700 “Soudan 2 Experiment Quarterly Status Report, January - March 1998”
D. S. Ayres

PDK 701 “Efficiency of the CEV Trigger”
T. Joffe-Minor

PDK 702 “Search for Nucleon Decay into K0 Modes Using Soudan 2”
W. Leeson (ANL), H. Tom, M. Sanchez, W. A. Mann, and D. Wall (Tufts)

PDK 703 “Kinematics and Scanning Comments for “Gold” Multiprong Events in Soudan 2”
W. Leeson (ANL), H. Tom, M. Sanchez, W. A. Mann, and D. Wall (Tufts)

PDK 705 “Vibration Life Test Studies Using US-178 Module at the Soudan 2 Site”
D. J. Jankowski

NuMI Notes:

NuMI-L-347 “MINOS Toroid Magnetic Measurements”
P. Schoessow, *et al.*

NuMI-L-375 “Neutrino Oscillation Physics at Fermilab: The NuMI-MINOS Project”
The MINOS Collaboration, D. S. Ayres, *et al.*

NuMI-377 “Searching for Neutrino Oscillations”
M. C. Goodman

NuMI-L-378 “Comments on MINOS Toroid Steel Properties”
P. Schoessow

STAR Notes

STAR Note 320 AGS/RHIC/ SN No. 071	"Luminosity Monitor Topics for RHIC Spin and A-A and p-A Interactions" D. Underwood
STAR Note 351	"Electromagnetic Calorimeter and Shower Maximum Detector Performance In 1997 Testbeam Run at BNL" S. Bennett, H. Spinka, D. Underwood, A. Yokosawa, *et al*.
STAR Note 358	"Physics with the STAR Detector at RHIC" T. LeCompte
STAR Note 368	"Quarkonium at STAR" T. LeCompte

Wakefield Notes:

WF Note 180	"Design of a Coherent Multimoded Dielectric Wakefield Accelerator" J. Power and W. Gai

VI. COLLOQUIA AND CONFERENCE TALKS

E. L. Berger

"Transverse Momentum Distribution for Massive Lepton Pair Production"
Physics Division Seminar, ANL-PHY, May 28, 1998.

M. Klasen

"Towards a Next-To-Leading Order Monte Carlo for Jet Photo- and Hadroproduction"
Workshop on Monte Carlo Generators for HERA Physics, Hamburg, Germany, April 27-30, 1998.

S. Kuhlmann

"Parton Distributions: Impact on Tevatron Physics"
Presented at the University of Chicago Physics Colloquium, Chicago, Illinois, April 20, 1998.

"Unpolarized Gluon Uncertainties and Direct Photon Measurements"
Presented at the RHIC Spin Workshop, Brookhaven National Laboratory, Upton, New York, April 26, 1998.

T. LeCompte

"High p_T Physics with the STAR Detector at RHIC"
Presented at Lawrence Berkeley Laboratory, Nuclear Science Division Seminar, Berkeley, California, February 10, 1998.

"Where is the Proton's Spin Hiding?"
Presented at the University of California, Davis Colloquium, Davis, California, April 7, 1998.

"High p_T Physics with the STAR Detector at RHIC"
Presented at the University of California, Davis Nuclear Physics Seminar, Davis, California, April 8, 1998.

"Quarkonium at STAR"
Invited visitor to the National Institute for Nuclear Theory, University of Washington, Seattle, Washington, May, 1998.

"Electromagnetic Signals at STAR"
Invited visitor to the National Institute for Nuclear Theory, University of Washington, Seattle, Washington, May, 1998.

“Physics Capabilities of the STAR Detector at RHIC”

Presented at the Workshop on Particle Distributions in Hadronic Collisions, University of Illinois at Chicago, June, 1998.

“Measurements of B Mesons Decays to CP Eigenstates”

Presented at the Workshop on CP Violation, Center for the Subatomic Structure of Matter, Adelaide, Australia, June-July, 1998.

S. Mrenna

“Pythia for $\mu^+\mu^-$ Event Generation”

Mini Workshop on Physics with the First Muon Collider, Fermilab, May 22-23, 1998.

“Are Soft Gluon Emissions Kinky?”

High Energy Physics Division Seminar, ANL-HEP, April 22, 1998.

“Multigluon Emission and Q_T Phenomena in Hadron Collisions”

Frontiers of Phenomenology, From Non-Perturbative QCD to New Physics (Pheno-CTEQ Symposium ‘98), Madison, WI, March 23-26, 1998.

“Simulating SUSY at Muon Colliders with Pythia”

Muon Collider Annual Collaboration Meeting, Orange Beach, AL, March 18-21, 1998.

L. J. Nodulman

“Electroweak Physics at the Tevatron”

Presented at Carnegie Mellon University, Pittsburgh, Pennsylvania, March 1998.

“Calorimetry”

Presented at the CDF 20th Anniversary Symposium, Fermilab, Batavia, IL, May 1998.

J. Norem

"Recent Progress in the Muon Collider Design"

High Energy Physics Lunch Seminar, ANL-HEP, June 2, 1998.

J. Repond

“A $\sqrt{s}$ = 1 TeV *ep* Collider at Fermilab”

6th International Workshop on Deep Inelastic Scattering and QCD, April 1998.

“Tests of QCD at HERA”

Illinois Institute of Technology, Chicago, IL, May 1998.

D. K. Sinclair

"Thermodynamics of Lattice QCD with 2 Quark Flavours: Chiral Symmetry and Topology"
Joint Workshop on Non-Perturbative Methods on Quantum Field Theory, Adelaide, South Australia, February 2-13, 1998.

H. M. Spinka

"Progress Report on the Design of the RHIC Pion Inclusive Polarimeter"
RIKEN-BNL Workshop on RHIC Spin Physics, Brookhaven, April 1998.

"The Physics of Nucleon-Nucleon Scattering"
Special Workshop on Hadron Physics in the 21st Century, George Washington University, March, 1998.

T. Tait

"Probing New Physics Through Single Top Production at Hadron Colliders"
Frontiers of Phenomenology, From Non-Perturbative QCD to New Physics (Pheno-CTEQ Symposium '98), Madison, WI, March 23-26, 1998.

D. Underwood

"Detector Limitations, STAR"
The RIKEN BNL Research Center Workshop, "RHIC Spin Physics," Brookhaven, NY, April 1998.

"Luminosity Monitor"
The RIKEN BNL Research Center Workshop, "RHIC Spin Physics," Brookhaven, NY, April 1998.

A. R. White

"Confinement and the Single Gluon Pomeron in QCD"
Low-x Physics Workshop at HERA, DESY-Zeuthen, Germany, June 3-6, 1998.

"Solving QCD Using Multi-Regge Theory"
Fourth Workshop on QCD, Paris, France, June 1, 1998.

"Future of the Theory Program"
ANL-HEP Division Retreat, Hinsdale, IL, May 28-29, 1998.

"Solving QCD Using Multi-Regge Theory"
Third Workshop on Continuous Advances in QCD, Minneapolis, MN, April 18, 1998.

"The Supercritical Pomeron in QCD"

LAFEX International Workshop on Diffractive Physics (LISHEP ‘98), Rio de Janiero, Brazil, February 17, 1998.

A. Yokosawa

“Collider Spin Physics at RHIC and STAR”
KEK, National Laboratory for High Energy Physics, Tsukuba, Japan, May 1998.

C. Zachos

“Time-Independent Wigner Functions”
Theoretical Physics Seminar, ANL-HEP, March 30, 1998.

“Time-Independent Wigner Functions”
Physics Department, University of Miami, Coral Gables, FL, February 25, 1998.

VII. HIGH ENERGY PHYSICS COMMUNITY ACTIVITIES

D. S. Ayres

Deputy Spokesperson of the MINOS Collaboration.

E. L. Berger

Session Chair, Symposium in Honor of Maurice Jacob, Geneva, Switzerland, March 27, 1998.

Session Chair, ATLAS Physics Workshop, Grenoble, France, March 29 - April 4, 1998.

Adjunct Professor of Physics, Michigan State University, East Lansing, MI, 1997 to present.

Member, High Energy and Nuclear Physics Advisory Committee, Brookhaven National Laboratory, Batavia, IL, 1995-2001.

Chair, Subgroup on SUSY Production Cross Sections, Fermilab Workshop on Physics at Run II -- Supersymmetry/Higgs.

Member, International Advisory Board, Fifth International Symposium on Weak and Electromagnetic Interactions in Nuclei (WIEN ‘98), Santa Fe, NM, June 14 - 21, 1998.

Member, Scientific Program Committee, Recontres de Moriond, “QCD and High Energy Hadronic Interactions,” Les Arcs, France, March 1998 and March 1999.

Organizing Committee, Seventh Conference on the Intersections Between Particle and Nuclear Physics, May-June, 1999.

Member, Local Organizing Committee, International conference on Kaon Physics (K’99), University of Chicago, Chicago, IL, June 21-26, 1999.

Member, International Advisory Committee, Eighth International Conference on Hadron Spectroscopy, Beijing, China, 1999.

International Advisory Committee, Frontiers in Science ‘99, Blois, France.

G. T. Bodwin

Organizer, Third Chicagoland Particle Theory Meeting, Argonne, IL, October 5, 1998.

T. LeCompte

Project Leader, Muon Upgrade - CDF

E. N. May

Member, staff of ESnet Steering Committee.

L. J. Nodulman

Joint CDF/D0 Fermilab CD Committee on Physics Analysis Software Functional Requirements "PASFRG".

Fermilab Director's Review Committee for U.S. CMS.

Lecturer, NATO Advanced Study Institute on Techniques and Concepts in High Energy Physics, St. Croix, U.S. Virgin Islands.

Co-Organizer of the Electroweak Physics Section for the Workshop "Weak Interactions and Neutrinos," (WIN99), Cape Town, South Africa.

L. E. Price

Chair, ESnet Steering Committee.

J. Repond

Member, International Advisory Committee, 6th International Workshop on Deep Inelastic Scattering and the QCD.

H. M. Spinka

Co-Spokesperson on BNL experiment E913.

Chairman, STAR Internal Review Committee for the Endcap Electromagnetic Calorimeter proposal from Indiana University Cyclotron Facility physicists.

Member, Organizing Committee, Workshop on Hadron Physics in the 21st Century," Washington, D.C., March 1998.

D. Underwood

Technical Director , STAR EMC.

Member, Technical Committee for STAR Experiment.

A. R. White

Co-Organizer, Fourth Workshop on Small-x and Diffractive Physics, Batavia, IL, September 17-20, 1998.

Organizer, Theory Institute on Deep Inelastic Diffraction, Argonne, IL, September 14-16, 1998.

Adjunct Professor of Physics, Northwestern University, Evanston, IL.

Member, International Advisory Committee, Xth International Symposium on Very High Energy Cosmic Ray Interactions, Gran Sasso, Italy, July 12-17, 1998.

Member, International Advisory Committee, International School on High Energy Physics LAFEX/CBPF (LISHEP '98), Rio de Janeiro, Brazil, February 1998.

A. B. Wicklund

Consultant to the Department of Energy, for the Brookhaven National Laboratory High Energy Physics Review, April, 1998.

C. Zachos

Member, Editorial Board, Journal of Physics A: Mathematical and General, (UK).

VIII. HEP DIVISION RESEARCH PERSONNEL

Administration

L. Price
D. Hill

Accelerator Physicists

M. Conde
W. Gai
J. Norem
J. Power
P. Schoessow

Experimental Physicists

D. Ayres
R. Blair
K. Byrum
S. Chekanov
M. Derrick
T. Fields
M. Goodman
D. Krakauer
S. Kuhlmann
T. LeCompte
T. Joffe-Minor
W. Leeson
S. Magill
E. May
B. Musgrave
L. Nodulman
J. Proudfoot
J. Repond
H. Spinka
R. Stanek
R. Talaga
J. Thron
R. Thurman-Keup
D. Underwood
R. Wagner
A. Wicklund
A. Yokosawa
R Yoshida

Theoretical Physicists

E. Berger
G. Bodwin
M. Klasen
J. -F. Lagaë
S. Mrenna
A. Petrelli
D. Sinclair
A. White
C. Zachos

Engineers, Computer Scientists, and Applied Scientists

J. Dawson
G. Drake
V. Guarino
W. Haberichter
N. Hill
J. Schlereth
X. Yang

Technical Support Staff

I. Ambats
G. Cox
D. Jankowski
T. Kasprzyk
C. Keyser
L. Kocenko
R. Konecny
E. Petereit
R. Rezmer
R. Taylor
K. Wood

Laboratory Graduate Participants

C. Allgower
N. Barov
J. Breitweg
A. Hardman
D. Mikunas
T. Tait
H. Zhang
P. Zou

Visiting Scientists

H. Lipkin (Theory)
X. Li (AWA)
G. Ramsey (Theory)
J. Uretsky (Theory)
T. Wong (AWA)